WATER CONSUMPTION PRACTICES IN MICHIGAN STATE UNIVERSITY RESIDENCE HALLS AND GENERAL FUND BUILDINGS

By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Environmental Engineering

2012

ABSTRACT

WATER CONSUMPTION PRACTICES IN MSU RESIDENCE HALLS AND GENERAL FUND BUILDINGS

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A water consumption investigation for Michigan State University's campus was continued because of increasing costs in purchasing water, as well as the direct translation to energy conservation, reduction in greenhouse gases, and a reduction in power plant wastes. By examining past and present water meter data for Residence Halls and General Fund Buildings, water using practices and equipment were outlined for improvement. With the available water data and estimated costs from various renovation projects, cost-benefit analyses were conducted. Pay-back periods varied between the projects, but with some as low as one year, it is clear that changes to Michigan State University's water infrastructure can result in significant economic improvements and reductions in water consumption.

ACKNOWLEDGEMENTS

This report was written with the persistent support, cooperation and efforts of individuals in various departments across Michigan State University and the surrounding community. Thank you for the continued efforts for promoting a sustainable campus.

Lynda Boomer, Physical Plant

Gus Gosselin, Physical Plant

Bob Ellerhorst, Power and Water

Amanda Groll, Power and Water

Diane Barker, Residential and Hospitality Services

Robert McCurdy, Residential and Hospitality Services

Chip Hornburg, Residential and Hospitality Services

Nestor DeOcampo, Facilities Planning and Space Management

Pat Curry, Maintenance Service Department

Ruth Kline-Robach, Water Research Institute

Ward Anderson, Michigan Medical Supply Products, Inc.

I would also like to express my sincere appreciation to my Professor and Advisor, Dr. Susan Masten, for her bright attitude and enthusiasm towards my academic and career goals. This report would not have been possible without her continued guidance.

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INTRODUCTION

It was reported in the 2011 Water Consumption Report that the campus of Michigan State University's (MSU) water consumption can be partitioned into 11 sectors. The water distribution of these sectors is displayed in Figure 1. The top 5 sectors make up 89% of MSU's water consumption, while chilled water and other (well main flushing, water bought for MSU, water sold from MSU, irrigation and athletic buildings) make up smaller portions. The five largest sectors and the corresponding volumes are: the Power Plant (411,000 KGAL per year), Research/South Campus Farms (393,000 KGAL per year), Residence Halls (336,000 KGAL per year), General Fund Buildings (290,000 KGAL per year), and unaccounted for water (286,777 KGAL per year).

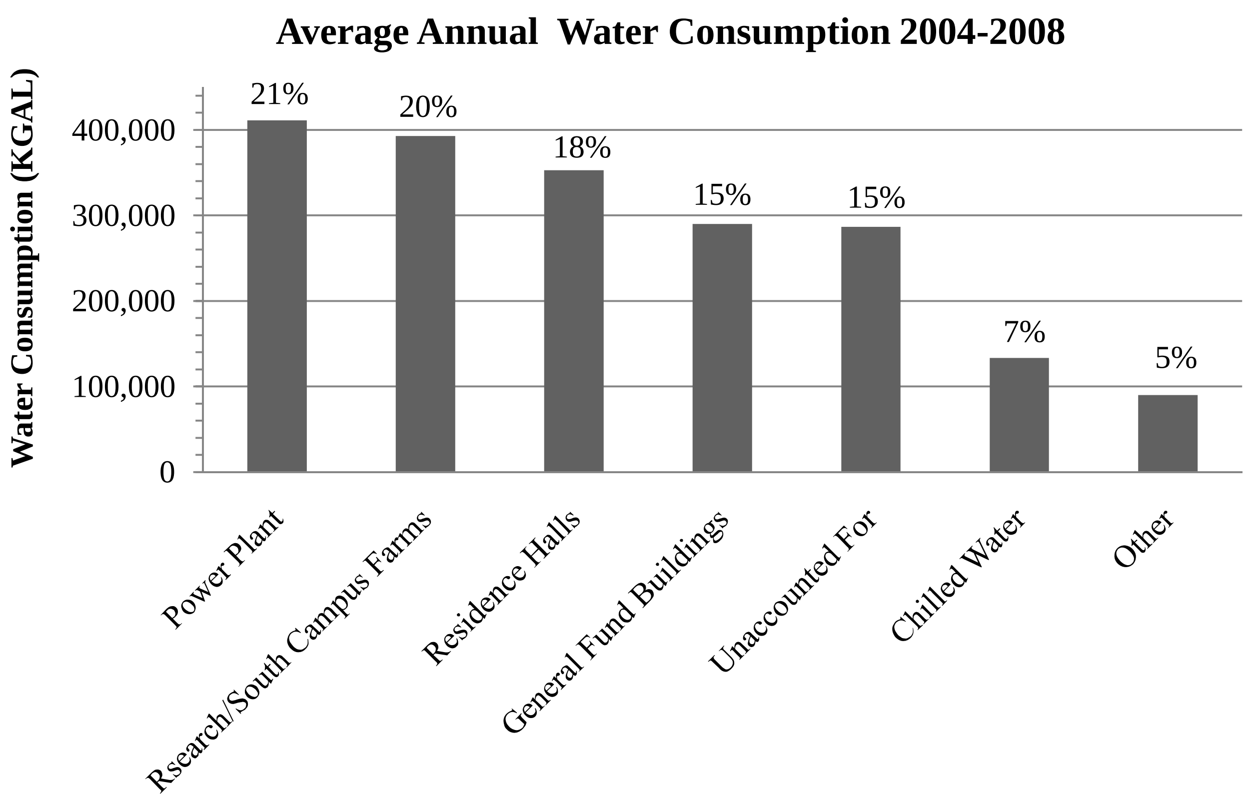

Figure 1: Distribution of annual water consumption on MSU's campus averaged 2004-2008 (Arnett, 2010).

The smallest sector, “Other”, includes water used to flush the distribution system and the well mains, water sold by MSU, water bought for MSU and water consumed in athletic buildings. The “unaccounted for” water corresponds to any water left over after calculating the other sectors. This sector can be associated with leaks in the distribution system, faulty meters or buildings that have sections (or the entire building) that are not metered.

Residence Halls and General Fund Buildings were the primary focus of the investigation because of the large portion of water consumed (33% combined) and the expectation that changes can be made to the two sectors that will improve water use. Residence Halls have undergone numerous renovations in order to improve water sustainability on campus. In order to inform future renovation decisions, it is important to quantify the effect that past renovations have had on water consumption. By outlining shortcomings and improvements to water consumption in these two sectors, swift action can be taken when unique funding opportunities present themselves.

WATER PRICES

The “Be Spartan Green” initiative prompted MSU to actively pursue improvements to energy, waste, and water sustainability. However, with funding sources limited it is important to address the most cost-effective issues first. The fundamental variable in determining the cost effectiveness of water use changes on campus is undoubtedly the cost of water.

While a majority of water used on MSU’s campus is pumped from the Saginaw aquifer, water is also purchased from East Lansing/Meridian Township and the Lansing Board of Water and Light. A small portion is also pumped from the Red Cedar River for irrigation purposes. The current water and sewage (pumping and sanitary treatment) costs for water being pumped from the Saginaw Aquifer is $3.81 per KGAL, while water and sewage from the Lansing Board of Water and Light costs $4.70 per KGAL ($2.75 water and $1.95 sewage) for a “large water user” (Ellerhorst, 2011). Because of the constant increase in energy costs, the cost to pump the water will continue to rise. On top of energy, privatization of water utilities could potentially increase the costs as well.

This is a particularly concerning issue for the state of Michigan because of the recently introduced House Bill No. 4112. This bill establishes a regional water and sewer authority to take control of most aspects of public water utilities. While this bill would apply to city water and sewer divisions across the State, one of the main objectives of this bill is to privatize the City of Detroit water utility, which serves over 4 million people. On March 17, 2011, Governor Snyder signed into law the Local Government and School District Fiscal Responsibility Act (Public Acts 4-7), which allows a state appointed emergency manager to overrule elected officials labor contracts, nullify contracts, and privatize city services. In Pontiac, this bill resulted in the replacement of city water treatment personnel with United Water Services, a private company recently indicted for violation of the Clean Water Act (Office of Public Affairs, 2010). Also, with the introduction of House Bill No. 4453, all governmental entities will not be able to compete commercially with the private sector. Section 4 of this bill prohibits governmental agencies to receive government funding which would support to compete with the private sector. This means that if this bill passes, a private contractor will likely take over and operate public water treatment plants (House Bill No. 4453, 2011). It was found that on an average across the United States, that privatization of water utilities increase the costs of water by 33% and sewer service by 63% (Food & Water Watch, 2009).

RESIDENCE HALLS

Because of the Residential and Hospitality Services' (RHS) intentional strides towards improving water sustainability, the residence halls are an excellent place to begin an investigation on recent practices to reduce campus water consumption. RHS has already dedicated a significant amount of funding towards improving water conservation. This allows specific renovations to be monitored, thus providing information on costs, water savings, and in turn a payback period. This data allows recommendations to be made on which renovations should take priority when unique funding opportunities present themselves. Recommendations for improvements to the General Fund Building renovations can also be prioritized by using available data acquired through the investigation of residence halls.

RESIDENCE HALLS: Water Consumption

As demonstrated by the previous Water Consumption Report (Arnett, 2010) there is a linear relationship between water consumption and the number of residents of a particular residence hall. Because of this expected trend, the water consumption was first converted to a per capita basis before analysis. Figure 2 displays the water consumption data for the 2009-2010 and 2010-2011 academic year (September to April). The monthly water consumption for the residence halls were averaged over the eight-month academic “year”, and then normalized by the number of residents that were residing or working there at that time. The use of residence halls are highly variable in the summer months and thus were not included in the water consumption calculations.

Figure 3 takes the same average monthly water consumption data from the residence halls, and compares the average of the two years. Any residence halls with incomplete data were left out of the diagram. A majority of the buildings are showing a decrease in water consumption while only a few outliers are observed for higher water usage. These outliers are VanHoosen, Mason/Abbot and Armstrong Halls.

The largest of the outliers is that of Armstrong Hall located in the Brody Complex. Taking a closer look at the water meter data reveals repeating values as well as sporadic changes in months prior to meter replacement in December, 2010. The 60% change in Armstrong’s per capita water usage is most likely related to meter replacement, highlighting the importance of a meter maintenance program.

Further studies should be conducted to determine the reason(s) for the increase in water consumption in VanHoosen and Mason/Abbot Halls.

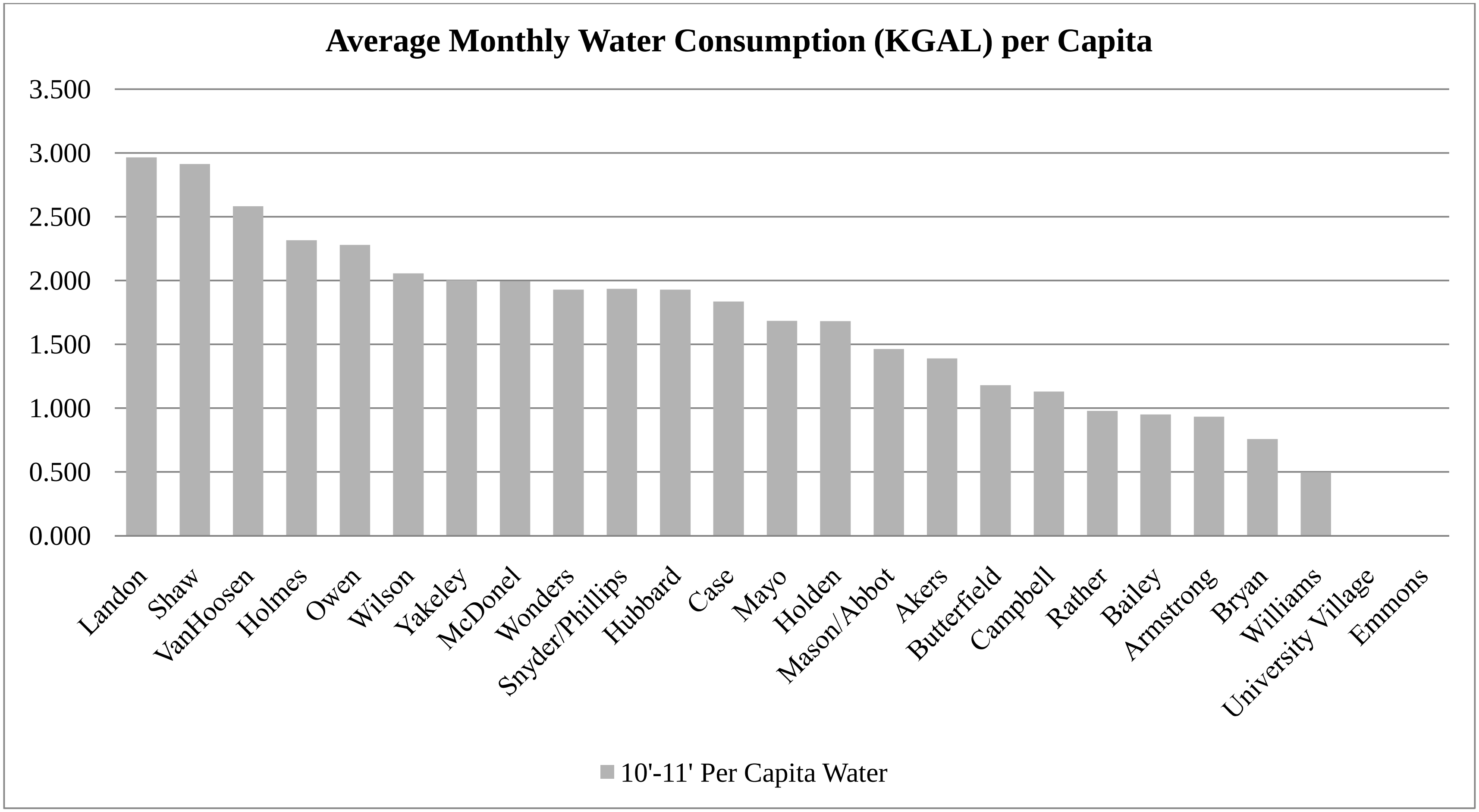

Figure 2: Average monthly water consumption per capita (KGAL/resident) for each Residence Hall.
***Note: Values of zero represent incomplete data due to lack of meter or construction activities.**

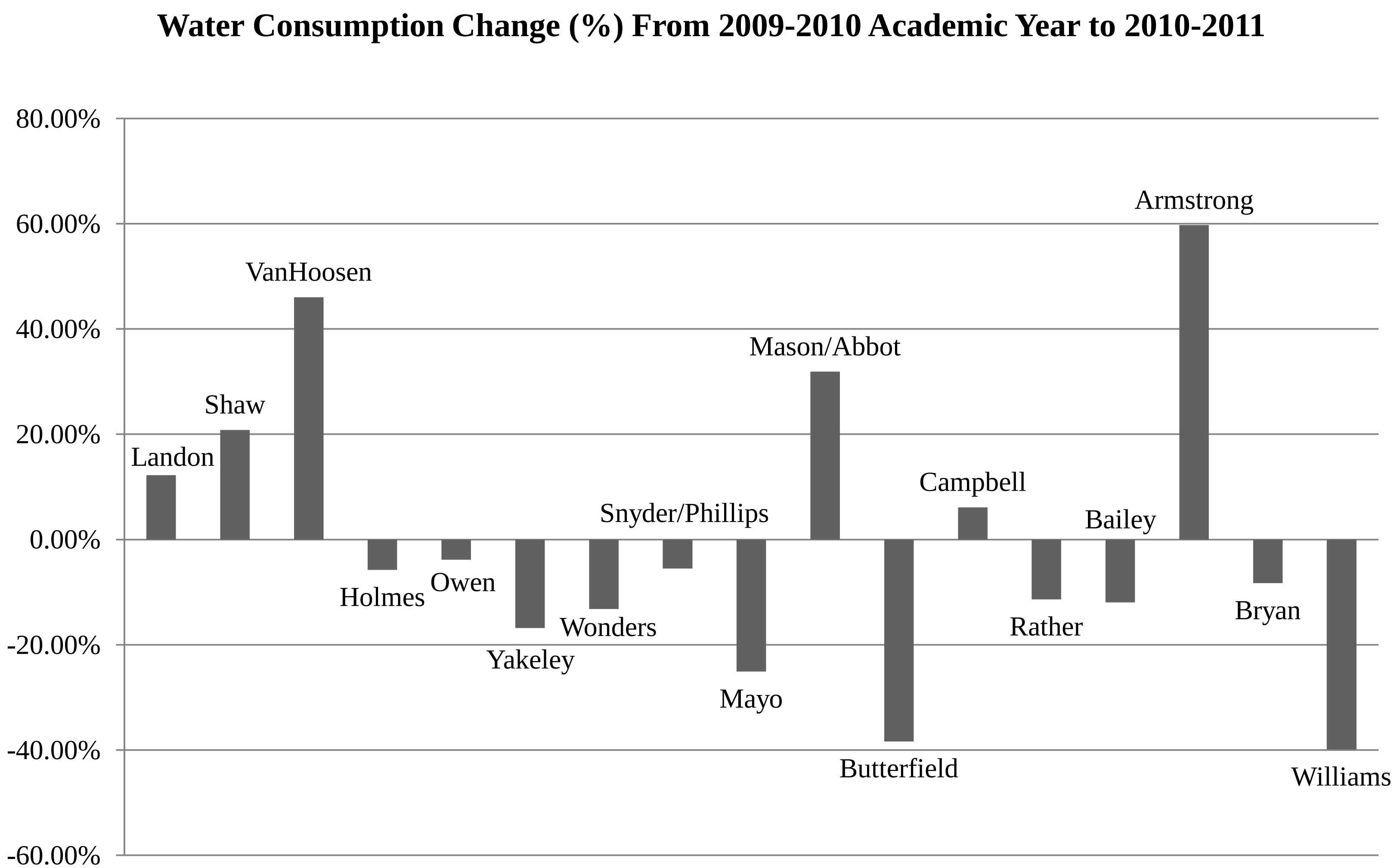

Figure 3: Change in average monthly water consumption from the 2009-2010 academic year to the 2010-2011 academic year. *Note: Residence Halls with missing data either of the two years were not included.

It was found by Arnett and Masten, that prior to the 2009 school year, the residence halls with the greatest per capita water consumption rates were Bailey, Owen, Bryan and Emmons Halls. While Owen Hall is still one of the top water consumers, Bailey, Bryan and Emmons have shown a significant decrease, most likely due to bathroom renovations discussed later in this report.

In addition to the bathroom renovations, the residence halls in Brody Complex are undergoing major renovations, including the installation of Energy Star appliances and reconstruction to allow more natural lighting. Emmons Hall was recently renovated \ opened for residency in August 2011. Sustainable features such low flow toilets, faucets and shower heads have been installed. Future water meter data will reveal the extent these changes have made on water consumption.

It is important to note, that nine out of the ten top water using residence halls are home to a cafeteria. This correlation was expected given data from the previous water consumption report. Because of this relationship, the newly renovated Brody Square (Brody Complex cafeteria building) was investigated to determine where water savings were achieved and at what cost to the facility’s employees.

RESIDENCE HALLS: Brody Complex

Brody Complex is comprised of six residence halls and a centrally located building referred to as "Brody Square," that houses the cafeteria, offices, classrooms, and more. Three of the residence halls in this complex, Bryan, Bailey and Emmons Halls, were the former top residence hall water consumers. It was believed that these residence halls had high water consumption rates due to the tank-style urinals that were still in use. In the summer of 2008, these urinals were removed and 1/8 gallon urinals were installed to replace them in areas where urinals were needed. Figure 4 shows the decline of water consumption after these renovations.

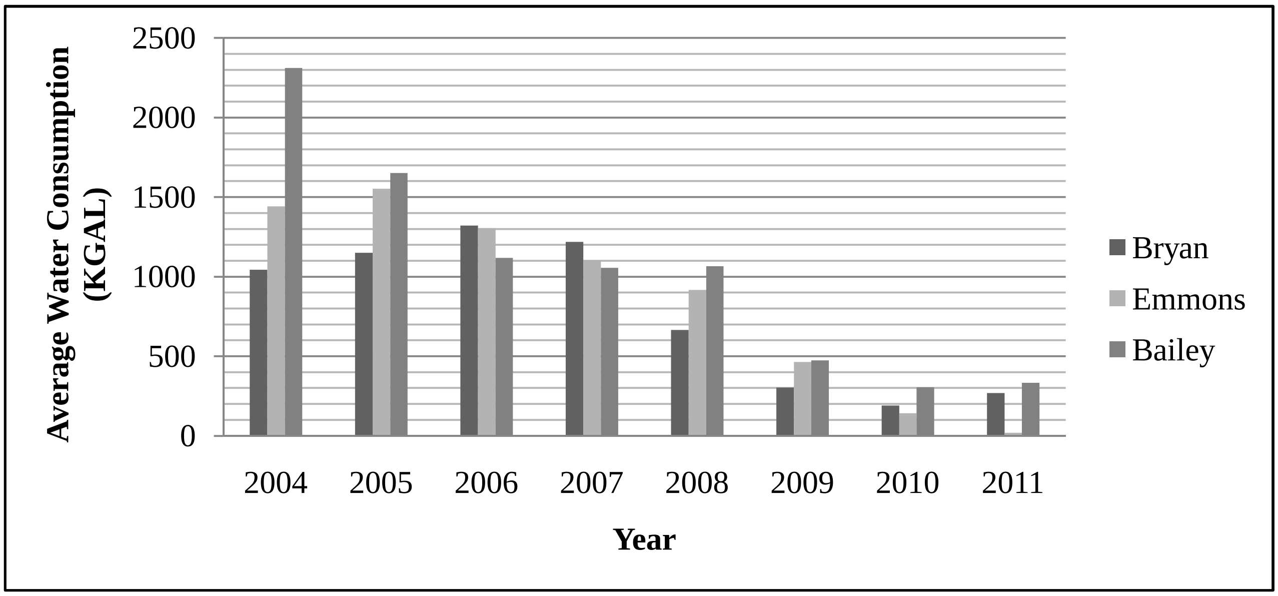

Figure 4: Average monthly water consumption for high water use Brody Complex Halls. * 2010-2011 meter data for Emmons Hall is incomplete due to construction activities. ** 2011 data is averaged over the first 6 months of the year.

The overall water consumption for these three facilities quickly declined after the replacement of the urinals. Looking at the per capita water usage in Figure 2, these three buildings now have some of the lowest water consumption rates amongst the residence halls. To help aid in improving other buildings' water consumption, a cost analysis was conducted. These bathroom renovations provided a unique opportunity to see the effect of a single renovation on the water consumption data.

RESIDENCE HALLS: Bryan Cost Analysis

After much deliberation over which building to use as a model for the cost analysis, Bryan Hall was chosen. It was important to find a renovation project that had sufficient impact on water consumption that the fluctuation could be monitored with the monthly meter readings. Among the Brody residence halls, Bryan Hall underwent the most extensive bathroom renovations. Bryan also had the fewest scheduling conflicts with non-bathroom renovation construction activities and meter replacements. This was important as we attempted to ensure that construction activities were not included in the cost analysis and meter replacement was not the cause of water consumption improvement.

Using physical plant work order records, a total cost of the renovations to replace urinals was calculated (Hornburg, 2011). A breakdown of these costs is found in Table 1. While efforts were made to include only costs associated with the urinal replacements, the results are expected to be conservative as more urinals were removed compared to the number being installed. The total cost for removing 39 existing tank-style urinals and installing 15 1/8 gallon urinals was $44,814. This includes project management, materials, labor and an asbestos survey.

Table 1: Summary of costs for Bryan Hall bathroom renovations.
(Source: Chip Hornburg, MSU Division of Residential and Hospitality Services)

Activity	Costs
Project Management	$754
Materials	$15,321
Labor	$28,167
Asbestos Invoice	$572
TOTAL	$44,814

Using the total cost for the Bryan Hall renovations, a payback period was determined. The calculations for the payback period are summarized in Table 2.

Shortly after the renovations took place, a new meter in Bryan Hall was installed. Over years of meter use, scaling and corrosion can occur which leads to a poor calibration of the instrument. Because of this, a new meter will likely affect the meter water consumption data so a payback period was calculated from data collected by both meters.

Table 2: Water and Cost savings for Bryan Hall bathroom renovations based upon water consumption.

	Before Meter Change (7/2008-6/2009)	After Meter Change (7/2009-6/2010)
water savings per month (KGAL)	785	980
$ savings per month ($4.70 water)	$3,691	$4,604
Payback Period (months)	12.14	9.73
Payback period (years)	1.01	0.81

With a calculated payback period of approximately one year, it is clear that replacing tank-style urinals with 1/8 gallon urinals has a significant environmental and economic effect. While it seems intuitively obvious that tank-style urinals are outdated, the revelation that the payback period is at most one year confirms the premise that any remaining tank-style urinals should be prioritized for replacement.

RESIDENCE HALLS: Brody Square

The Brody Square building, in the center of Brody Complex, was renovated with extensive consideration into sustainability. The project began in January 2009 with the completion of Phase 1 in August 2010 and the completion of Phase 2 in August 2011 (Barker, 2011). Phase 1 consisted mainly of the renovations to the new cafeteria, whereas Phase 2 consisted of the renovations to first floor facilities. One of the goals of this construction project is to achieve Leadership in Energy and Environmental Design (LEED) – Silver Certification. To meet this certification, a variety of sustainable practices were used, including: the installation of sustainable construction materials, low flow plumbing fixtures, advanced heating ventilation and air-conditioning (HVAC) controls, and a food waste pulper/extractor green balcony, along with natural light building design and rainwater reuse. Of the long list of sustainable features implemented at Brody Square, those that are associated with water consumption are discussed in this report.

RESIDENCE HALLS: Food Waste Pulper/Extractor

Rather than using a traditional garbage disposal system, Brody Square directs all post-consumer food waste into a pulper/extractor. A basic flow diagram for a food waste pulper/extractor is displayed in Figure 5. Rather than running water constantly to keep solids flowing through sanitary pipes, a pulper/extractor recycles the water needed to crush food waste into a pulp and then extracts this pulp into a storage container, where it can be collected and used for compost. While in essence this method consumes no water, realistically the water that was pressed out from the food waste needs to be replaced with fresh water continuously to keep the pulper/extractor running efficiently. This make-up water has a flow rate of approximately 1 gpm, whereas the "garberator" that is used at a majority of the MSU cafeterias has an approximate flow rate of 10 gpm (Pipper, 2011).

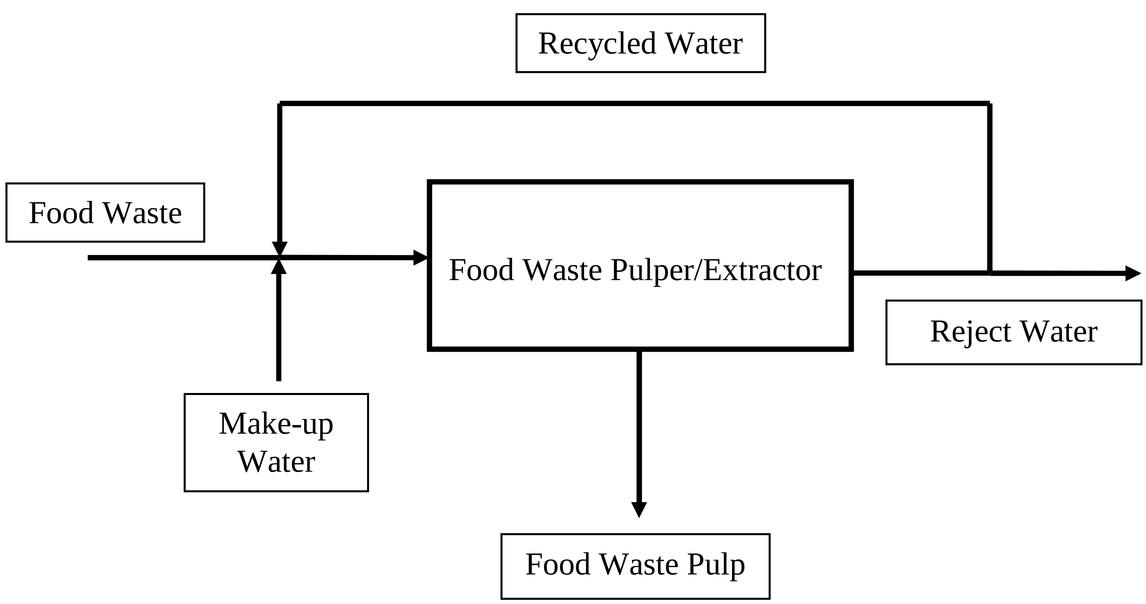

Figure 5: Flow diagram for a food waste pulper/extractor.

A picture taken of the food waste pulper in Brody Square is shown in Figure 6. The difficulties with using this piece of equipment are mainly limited to the proper disposal of fibrous food waste. These types of food waste must be thrown away manually rather than run through the pulper as they will bind the shredding mechanism, bringing the pulper to a halt.

Figure 6: Brody Square food waste pulper/extractor equipment.
***For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this thesis.**

The approximated water consumption savings allow for the completion of basic cost analysis calculations. Assuming the new pulper and old garberator are both in use 12 hours per day for 30 weeks a year (two 15 week semesters), it was determined that the operating time is 2,520 hours per year. Operating time will vary depending on demand. Table 3 shows the result of these calculations.

Table 3: Food waste pulper/extractor water and cost savings.

Previous Water Usage (gpm)	10
Pulper Water Usage (gpm)	1
Water Savings (gpm)	9
Annual Operating Time (hours)	2520
Annual Water Savings (KGAL)	1,361
Annual Savings	$6,396

While these calculations are crude, they do demonstrate a significant savings in both cost and water consumption. A unanimous decision amongst Brody Square kitchen staff involved in a focus group conducted in December 2011, was that the water savings associated with the food waste pulper outweighs the minor difficulties associated with the use of this equipment (Brody Square Focus Group, 2011).

With the installation of a food waste pulper, the waste food pulp must be dealt with properly. Once shredded and dewatered, the pulp is sent to a hopper for storage. Figure 7 displays a picture of the hopper in the Brody Square facility. Disposal of this food waste is another difficulty resulting from the use of the food waste pulper/extractor unit. Previously, the food waste was disposed of down the sewer system or it was picked up with the garbage. Now the material must be disposed of as garbage or used in another process. Fortunately, the pulp can be composted and/or added to manure from the MSU animal feeding operations to be digested anaerobically. Presently, studies of these uses are ongoing. The main limitations with composting/anaerobic digestion are the regulations governing the amount of food waste that can be combined with animal waste for land application (Michigan Department of Environmental Quality, 2008). Another problem with the unit is the corrosion of pipes, valves, and other plumbing material by the corrosive gases produced during decomposition of food waste or by the acidity present in the food waste itself.

Figure 7: Food waste pulp stored in hopper at Brody Square.

Based on these studies, it is recommended that the food waste pulper/extractor equipment be installed during proposed cafeteria renovations. It is believed that the difficulties of the equipment can be managed to make it both economical and functional. When installing this equipment, the following issues should be seriously considered:

- Proper disposal of fibrous food waste
- The use of corrosion resistant pipes and storage containers for the food waste
- Odor control for the stored food waste
- Transport and final use of the food waste pulp

RESIDENCE HALLS: Rainwater Collection

A unique addition to Brody Square was the addition of a rainwater collection system to conserve water. This method involves collecting rain from the roof of a building, and directing it towards a large cistern. In the case of Brody Square, this cistern is located underground near the front entrance to the building. When this cistern is filled with water, the first floor restrooms are able to use this water to flush the toilets. While this method would theoretically cause the toilets not to consume any purchased water, weather patterns are unpredictable, and thus, so is the amount of water stored in the cistern.

Using rainwater collection can be very convenient with the proper setup. Automatic valves allow the bathrooms to be flushed by the potable water lines when the cistern is low on water. This makes the bathroom operational even in times of low precipitation. The Brody Square facility currently only uses rainwater collection for an additional water supply but greywater reuse is also available. This includes reuse of laundry, dish-washing and bathing water; commonly used for irrigation purposes. Changing the stigma of greywater and proper quality monitoring to pass state codes would be the primary difficulties to implementing more water reuse.

The Brody Square focus group did not report negative feedback for the presence or the use of bathrooms that took advantage of collected rainwater (Brody Square Focus Group, 2011).

RESIDENCE HALLS: Low Flow Fixtures

As mentioned earlier, during recent renovations, low flow fixtures were installed in Brody Complex to save water and reduce associated costs. Sloan Solis EAF-275 aerator spray heads for the hand washing valves and the Sloan Solis 8111 duel flush valves for the toilets were installed in Brody Square (McCurdy, 2011). Both of these fixtures utilize infrared sensors to detect the user.

Table 4: Low flow fixtures used in Brody Complex.

Sloan Solis EAF-275 Hand Washing Valve	0.5 gallons per minute
Sloan Solis 8111 Duel Flush Valves	1.6 and 1.1 gallons per flush

It is difficult to determine the water savings associated with duel flush valves, as it depends largely on the user and the presence/absence of urinals. However, commercial vendors for dual flush valves are generally credited a 30% decrease in water consumption from the federal standard 1.6 gpf toilets (Harrison, 2010).

Hand washing valves are highly variable in both usage and flow rate. The user has the ability to choose the flow rate, making a thorough cost analysis difficult. However, comparing the flow rate of the Solis EAF-275 hand washing valve to the federal standard of 2.2 gpm, a water savings of 77% is expected (Environmental Protection Agency, 2008). This value also assumes that the faucet is turned on for the same amount of time for each usage. This is not likely the case because automatic valves turn off automatically once the user’s hands leave the proximity of the faucet. Therefore, the water savings are expected to be greater than 77% than the federal standard.

RESIDENCE HALLS: Smart Meters

Standard water meters require someone to check them on a monthly basis to receive that month's water consumption. A smart meter on the other hand is electronic, automatically feeding data to a computer or data center. The benefit of the smart meter is that it allows a continuous display of the water consumption in a building. Figure 8 displays a picture of one of these monitors in the Brody Square facility. This monitor currently shows the change in annual water consumption for 2009 and 2010. However, a continuous water consumption display would look similar.

Figure 8: Steam, energy and water usage display in Brody Square.

The effect of the installation on water consumption is not known, but a study conducted of the residents of Carlsbad, CA demonstrated that the continuous feedback regarding personal water usage resulted in a decrease in water consumption ranging from 8% to 27%, depending on the motivation of the individual to conserve water (Schultz, 2009). This study was completed on residents of the community, but similar results are likely transferable to residence halls in a university. Students in a residence hall however, do not directly pay for their water use. Future water meter data where smart meters are implemented will display how this affects water use.

Placing these Smart Meter displays at the entrance to residence halls may encourage students to conserve their water usage on a daily basis. Most members of the Brody Square focus group were not aware of these monitors, highlighting the importance of placing these displays in a prominent location within a building (Brody Square Focus Group, 2011).

GENERAL FUND BUILDINGS

Activities in general fund buildings account for 15% of MSU's campus water consumption and therefore are another sector where conservation measures can be made. As with the residence halls, fixture and toilet/urinal replacements were investigated. However, "wet"[1] laboratories, which are consumers of significant quantities of water, are located in numerous general fund buildings but are not located in residence halls[2]. In the previous water consumption report, a significant correlation was reported between the number of laboratories in a building and the buildings water consumption (Arnett, 2010).

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[1] These include biology, chemistry, and physics type laboratories. These do not include electronic and computing focused laboratories.

[2] An exception to this is Holmes Hall. Holmes Hall is a residence hall that houses many laboratories for introductory classes in the Lyman Briggs program.

GENERAL FUND BUILDINGS: Water Consumption

Using available water meter data, a comparison was made between the average yearly water consumption examined in the previous water consumption report and the average yearly water consumption from 2009-2011. Table 5 displays the general fund building water usage data.

Table 5: General fund building average annual water usage trend.

Bldg#	Building Name	Average Annual Water Usage 2004-2008 (KGAL)	Average Annual Water Usage 2008-2011 (KGAL)	Change in Water Usage (%)
0055	KELLOGG CENTER	48,560	34,772	-28.4%
0446A	VETERINARY RESEARCH CENTER - LARGE ANIMAL BARN	46,560	59,070	26.9%
0086	PLANT & SOIL SCIENCES BUILDING	44,470	27,572	-38.0%
0189	REGIONAL CHILLED WATER PLANT NO. 1	32,130	14,678	-54.3%
0160	BIOMEDICAL PHYSICAL SCIENCES BUILDING	29,150	32,380	11.1%
0178	PLANT BIOLOGY LABORATORIES	12,770	14,991	17.4%
0132	ANTHONY HALL	12,350	12,332	-0.1%
0170	VETERINARY MEDICAL CENTER	9,250	9,027	-2.4%
0081	ENGINEERING BUILDING	7,770	7,212	-7.2%
0203A	ENGINEERING RESEARCH COMPLEX	6,900	9,280	34.5%
0068	LAUNDRY BUILDING	6,800	6,427	-5.5%
0186	FOOD SAFETY AND TOXICOLOGY	4,570	3,579	-21.7%
0006	UNION BUILDING	3,960	2,854	-27.9%
0024	NATURAL SCIENCE	3,470	5,037	45.2%

Table 5 (cont'd)

Bldg#	Building Name	Average Annual Water Usage 2004-2008 (KGAL)	Average Annual Water Usage 2008-2011 (KGAL)	Change in Water Usage (%)
0212A	PAVILION FOR AGRICULTURE AND LIVESTOCK EDUCATION - HORSE BAR	2,450	2,239	-8.6%
0083	MSU COLLEGE OF LAW	2,060	2,708	31.5%
0029	KEDZIE HALL (NORTH AND SOUTH)	1,730	686	-60.3%
0003	OLIN MEMORIAL HEALTH CENTER	1,600	1,348	-15.8%
0084	COMMUNICATION ARTS & SCIENCES BUILDING	1,300	3,081	137.0%
0080	BUSINESS COLLEGE COMPLEX	1,090	1,088	-0.2%
0002	BERKEY HALL	940	1,219	29.7%
0085	WHARTON CENTER	900	781	-13.2%
0035	COMPUTER CENTER	850	719	-15.4%
0128	NISBET, STEVEN S., BUILDING	790	1,090	38.0%
0087	PUBLIC SAFETY	770	881	14.4%
1121	MUSIC/MUSIC PRACTICE	740	677	-8.5%
0027	PSYCHOLOGY BUILDING	620	595	-4.1%
0005	HUMAN ECOLOGY	570	420	-26.3%
0163	CHEMISTRY BUILDING	550	604	9.8%
0177	PACKAGING	520	479	-7.8%
0171	FOOD STORES	430	626	45.6%
0214	RADIOLOGY BUILDING	430	1,571	265.3%
0154	MANLY MILES BUILDING	330	383	16.1%
0091	FARRALL AGRICULTURAL ENGINEERING HALL	300	352	17.2%
0219	PARKING RAMP NO. 1 SHAW LANE	270	201	-25.4%
0060	CENTRAL SERVICES BUILDING	80	79	-1.4%
2000	CLINICAL CENTER	40	42	4.3%

The data presented in Table 5 is given in KGAL/yr and is in order of the former highest water consuming buildings to the lowest. While a few of the buildings show a large percentage change in water use, water consumption rates in the top water using buildings remain constant. It is important to note, that a majority of the buildings that have the highest water consumption rates house “wet” laboratories: Plant and Soil Science (139 labs), Biomedical Physical Sciences (183 labs), Plant Biology Laboratory (137), Anthony Hall (77 labs), Veterinary Medical Center (78 labs), *et cetera* (Arnett, 2010).

Using updated water consumption data as well as the number of laboratories in each general fund building, a linear trend plot was created in Figure 9. Similar to that of the previous water consumption report, the plot shows a clear relationship between the number of laboratories and the water consumption for that building. The most recent data shows an R^2 value of 0.82, compared to the previous value of 0.61. This increase in linear correlation may be due to increasing overall building water efficiencies but unchanging laboratory water efficiencies.

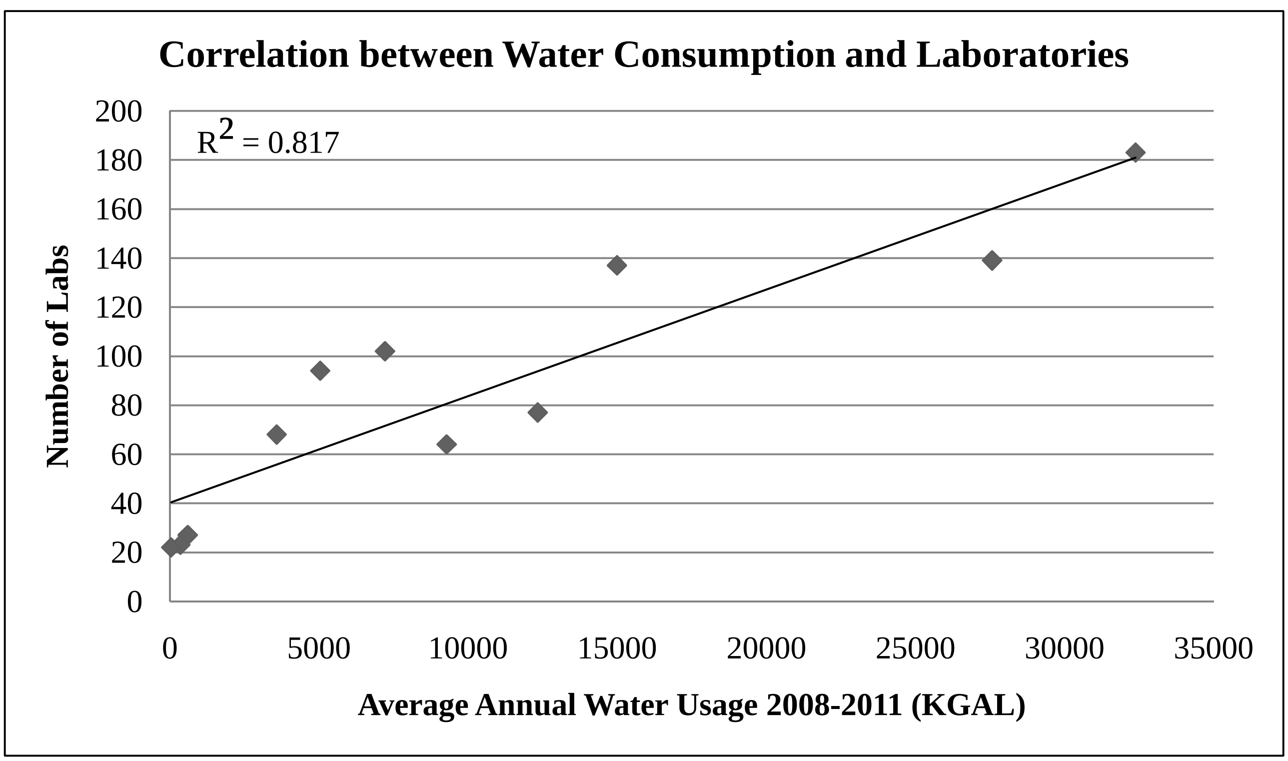

Figure 9: General fund building water consumption compared to the number of laboratories.

GENERAL FUND BUILDINGS: Plumbing Fixtures Cost Analysis

As seen with the cost-benefit analysis with the residence halls, bathroom renovations can have a significant impact on water savings. Unfortunately, no extensive bathroom renovations in General Fund Buildings have been completed recently, for which, data are available. Because of this, a cost-benefit analysis was conducted using the renovation costs from Bryan Hall, plumbing fixture cost estimates and expected water savings for particular bathroom upgrades.

First, a new total cost was calculated in attempt to determine a more general unit cost for plumbing fixtures. This was necessary because the Bryan Hall renovations included removal of both wall tanks and the urinals and this effort did not result in complete replacement of all of these plumbing fixtures. Table 6 shows how the total unit cost was calculated. The costs associated with project management were the result of 16 hours of oversight. Because the Bryan Hall project involved the installation of 15 urinals, the unit cost for project management was determined by dividing by the number of urinals installed. These 16 hours of labor are also associated with the removal of 39 urinals and wall tanks, making this a conservative unit cost. The total material cost for 16 urinals was also included in the work orders. From this total cost it was determined that each urinal costs $737.76 for the actual fixture. The delivery prices found in the work orders were associated with the delivery of 11 urinals. Because the need to deliver the materials is independent of how many urinals are being replaced, the delivery charge was left unchanged. The plumbing costs involved a section of the Bryan Hall renovations (Bryan Hall Work Order: 471616) that were associated with removal of 10 urinals, 4 tanks and the installation of 4 urinals. This cost of $5,625.71 was divided by 14 urinals to receive a unit cost.

While the plumbing associated with removing a urinal permanently compared to replacing urinals is not the same, it is likely that this introduced a small error compared to the overall cost. Masonry is not included in this cost analysis as it is expected to be minimal for most plumbing fixture retrofits.

Table 6: Costs used to determine total unit plumbing fixture cost.

Project Management (16 Hours, 15 urinals)	$754.28
1/8gpf Urinals (16 units)	$11,804.12
Delivery (labor + truck rental)	$153.92
Plumbing (remove 10 urinals & 4 tanks, install 4 urinals)	$5,625.71
Project Management (per urinal)	$50.29
1/8gpf urinal (unit cost)	$737.76
Delivery	$153.92
Plumbing (per urinal)	$401.84
Total Unit Cost	$1,343.80

Through personal communication with Pat Curry, a MSU plumbing inspector, an estimate of $1,200 was obtained for the installation of 1/8 gpf urinals was given (Curry, 2011). Because of the similarity with the calculated values from Bryan Hall and the estimated prices given by Maintenance Services, cost estimates for various plumbing fixtures were used confidently in the cost-benefit analysis.

With an approximate cost for the replacement of a single plumbing fixture and the volume of water used per flush, a cost benefit analysis can be constructed if the amounts of flushes are known. In September 2008, the Costs & Returns for Environmental Stewardship Team (CREST) also conducted a cost-benefit analysis on specific plumbing fixtures in the first floor restrooms of the MSU main library (Peralta, 2008). While they did not have the luxury of a bathroom renovation project to verify their cost estimates, they did have a robust method of determining the amount of flushes. CREST made use of infrared sensors that made automated counts of restroom visitors to the first floor men and women's main library restrooms. These sensors were monitored for an entire academic year (fall and spring semesters). From this, it was determined that the two bathrooms jointly serve 800 visitors daily. The men and women's restroom included five toilets each, with the men's restroom also having six urinals. To avoid the complexities of the probability of a male using the urinal, the women's restroom was used to determine the average amount of flushes per toilet. Assuming 50% of the 800 daily bathroom visitors were female and all five toilets were used evenly, an average of 80 flushes per day per toilet was calculated. The main library first floor restrooms are likely in the top tier for bathroom visitors. This is important to note when analyzing the payback periods for various fixtures.

Table 7 demonstrates the process for calculating the payback period for the plumbing fixtures. Using the prices found in Table 8, the payback period for replacing a 3.0 gpf urinal with a 1/8 gpf urinal was calculated. For a top tier water user, like the first floor library restroom, a payback period of 3.8 years is expected.

Table 7: Payback period calculations for replacing a 3.0 gpf urinal with a 1/8 gpf urinal.

Number of Flushes per Day	Water Savings (gpf)	Water Savings per Year (KGAL)	Cost Savings per Year	Payback Period (years)
10	2.875	10.5	$39.98	30.0
20	2.875	21.0	$79.96	15.0
30	2.875	31.5	$119.94	10.0
40	2.875	42.0	$159.92	7.5
50	2.875	52.5	$199.91	6.0
60	2.875	63.0	$239.89	5.0
70	2.875	73.5	$279.87	4.3
80	2.875	84.0	$319.85	3.8
90	2.875	94.4	$359.83	3.3

100	2.875	104.9	$399.81	3.0

Substituting the corresponding costs for various plumbing fixtures, a summary of payback periods was constructed. To be consistent, the estimated cost for a 1/8 gpf urinal was used rather than what was calculated in Table 8. This resulted in a slightly shorter payback period. All of these calculations were determined using the 80 flushes per day estimate, thus, the data from this Table 8 is most useful when applied to high traffic buildings.

Table 8: Plumbing fixture payback periods for high traffic restrooms.

Plumbing Fixture	New Unit Cost	Water Savings per Year (KGAL)	Cost Savings per Year	Payback Period (years)
3.0 gpf to 1.0 gpf Urinal (manual)	$750.00	58.4	$222.50	3.4
3.0 gpf to 1/8 gpf Urinal (automatic)	$1,200.00	84.0	$319.85	3.8
1.0 gpf to 1/8 gpf Urinal (automatic)	$1,200.00	25.6	$97.35	12.3
3.5 gpf to 1.6 gpf Toilet (manual)	$750.00	55.5	$211.38	3.5
3.5 gpf to 1.6 gpf Toilet (automatic)	$1,000.00	55.5	$211.38	4.7

Assumptions: (a) High traffic building (80 flushes per day)
(b) Water savings according to manufacturer specifications
(c) Urinal usage is equal to toilet usage
(d) All fixtures in a bathroom are used equally

In general, choosing an automatic flush over a manual flush costs an extra $250 to the initial price of the plumbing fixture. While these types of fixtures do not reduce water consumption, they are frequently used for convenience and improved sanitation. Using the current price of MSU's well water of $3.81 per KGAL, cost savings are clearly observed with any outdated plumbing fixture (greater than 3.0 gpf). Even the more costly automatic flush units provide a payback period of less than five years. Upgrading an already low flow urinal, however, does not provide such a significant improvement in water savings.

It is believed that the date of construction or last renovation will aid in determining the presence of outdated urinals (Curry, 2011). In 1992, federal regulations required that any new toilets must meet a flow rate of 1.6 gpf or less; however, toilets already in place were not required to be upgraded (Environmental Protection Agency, 2008). Investigating which buildings were built prior to 1992 and which have not had renovations since that time will help estimate the amount of outdated urinals are still present. Table 9 lists the date of original construction of the general fund buildings discussed in this report. Please note that many of these facilities have had additions since 1992. Therefore, only portions of the building older than 1992 would house outdated plumbing fixtures.

Table 9: Original construction year of metered general fund buildings. (Source: Facilities Information Tool, http://www.eas.msu.edu/fitii/)

Building Name	Original Construction Year
UNION BUILDING	1924
HUMAN ECOLOGY	1924
KEDZIE HALL (NORTH AND SOUTH)	1927
OLIN MEMORIAL HEALTH CENTER	1939
BERKEY HALL	1947
NATURAL SCIENCE	1948
COMPUTER CENTER	1948
FARRALL AGRICULTURAL ENGINEERING HALL	1948
CENTRAL SERVICES BUILDING	1948
PSYCHOLOGY BUILDING	1949
KELLOGG CENTER	1951
ANTHONY HALL	1955
VETERINARY RESEARCH CENTER - LARGE ANIMAL BARN	1958
MANLY MILES BUILDING	1959
ENGINEERING BUILDING	1961
CHEMISTRY BUILDING	1963
PACKAGING	1964
FOOD STORES	1964
VETERINARY MEDICAL CENTER	1965

Table 9 (cont'd)

Building Name	Original Construction Year
PLANT BIOLOGY LABORATORIES	1966
LAUNDRY BUILDING	1968
MUSIC/MUSIC PRACTICE	1968
REGIONAL CHILLED WATER PLANT NO. 1	1971
NISBET, STEVEN S., BUILDING	1973
PUBLIC SAFETY	1975
CLINICAL CENTER	1976
COMMUNICATION ARTS & SCIENCES BUILDING	1981
WHARTON CENTER	1982
PLANT & SOIL SCIENCES BUILDING	1986
ENGINEERING RESEARCH COMPLEX	1986
BUSINESS COLLEGE COMPLEX	1993
PAVILION FOR AGRICULTURE AND LIVESTOCK EDUCATION - HORSE BAR	1996
FOOD SAFETY AND TOXICOLOGY	1997
MSU COLLEGE OF LAW	1997
RADIOLOGY BUILDING	1998
BIOMEDICAL PHYSICAL SCIENCES BUILDING	2001
PARKING RAMP NO. 1 SHAW LANE	2002

Plumbing fixtures are often upgraded when funding is available and when additions are added. Therefore, this list can only be used to guide further investigation. A more complete list of original construction dates and additions for both general fund buildings and residence halls is located in the appendices. With this data in mind, the percentage of campus buildings that likely house outdated plumbing fixtures was loosely estimated to be 70% (Curry, 2011).

The results from the cost analysis clearly validate a recommendation of replacing all outdated plumbing fixtures with low flow units in high traffic buildings. Both manual and automatic flush valves provide great water savings, thus leaving that determination to preference. It is important to note, while automatic flushing units have improved convenience and sanitation, they also have a higher repair cost. If an automatic flush valve battery is damaged, replacement can run from $250-$300, whereas a manual valve would likely only cost $25 (Curry, 2011).

GENERAL FUND BUILDINGS: Laboratory Equipment

As demonstrated earlier in this report, there is a linear correlation between the number of laboratories in a building, and that buildings water consumption. This presents an excellent area to investigate water consumption on MSU's campus. MSU is home to nearly 2,000 laboratories that vary in type and age of equipment. Ideally, a database would exist that documents all of the pieces of equipment available and their characteristics. Some of these details include: equipment age, model, size, flow rates, energy consumption, and uses. Currently the Facilities Planning and Space Management (FPSM) is creating this type of database, starting with energy intensive equipment and eventually including water consuming equipment (DeoCampo, 2011). This data will aid in constructing a campus wide cost-benefit analysis for specific laboratory equipment. Until a complete database is created, only a cursory analysis can be accomplished by piecing together portions of the available data in order to determine the benefits of equipment retrofits. Gathering data for the water consuming equipment is planned to start towards the end of 2012.

GENERAL FUND BUILDINGS: Autoclaves/Sterilizers

Autoclaves/sterilizers are used in laboratories to sterilize equipment by exposing bacteria to high temperatures and pressures. Generally, these high temperatures and pressures are created by filling the vessel with saturated steam. What happens to this steam after sterilization varies depending on the model of the autoclave. One way to dispose of this steam is to collect the resulting condensate and send it to the sanitary sewer system. To use this disposal method it is important to cool the water back down to 140°C, to prevent pipe damage, before it enters the sanitary system. To cool the condensate, a potable water stream is added to the effluent of the autoclave. The potable water is set to a flow rate that sufficiently attenuates the resulting streams to a temperature of 140°C or lower. This addition of potable water potentially contributes to a significant amount of water consumed in laboratories at MSU. Because some models of autoclaves take many hours to start up, active laboratories are inclined to leave the autoclave on idle 24 hours a day. This results in water flow in the potable water line 24 hours a day / 7 days a week, even when the equipment is not in use.

To decrease the water consumption resulting with these types of autoclaves, various manufacturers produce "water conservation retrofit kits" (Tanner, 2005). These water conservation kits are attached to the effluent line of the autoclave, where a solenoid valve replaces needle valves and a temperature sensor operates the solenoid to only add potable water as it is needed to keep the water temperature less than 140°C. Additionally, a fixed orifice is used to limit the overall flow when the system is in operation. A manufacturer of the water conservation kit claims that the water consumption by the autoclave process can be reduced by 62%. In addition to the water conservation kit, it is also possible to add a digital timer to schedule on/off times of the autoclave. This would allow the autoclave to be automatically turned off at night and/or on weekends and turned on early enough in the morning to be ready for use by staff members as they arrive, making the equipment use convenient but eliminating the waste of water during nonuse times.

In May 2006 the Utilities and Plant Engineering Department of the University of Michigan conducted a pilot study to confirm the 62% water savings claimed by the manufacturer (Wells, 2006). The pilot study was conducted on six autoclave units in the E.H. Kraus (Natural Science) Building prep rooms. For this pilot study, it was assumed the average water usage during idle time is 60 gallons per hour. With the installation of the water conservation kit, the average water usage was reduced to 23 gallons per hour. Using water and sewer price of $4.54 per CCF ($6.07 per KGAL), the installation of a conservation kit can result in a cost savings of $1,967 per year for a single autoclave running 24 hours per day (Wells, 2006).

The pilot study also examined the benefits of an on/off schedule for the autoclaves. Using the price of water and sewer, the amount of potable water needed for tempering, and an estimation of steam entering the sanitary system, it was determined that the autoclave costs $0.46 per hour to run. If the autoclave cost $0.46 per hour to run, scheduling the autoclave to turn off 6 hours per night (12:00am to 6:00am) results in a savings of $1,007 per year. The total project cost for the retrofit of six autoclaves with varying operating hours, as some were not in operation 365 days a year, was $18,500. Taking into account the reduced water flow rate and the cost savings from the on/off schedule, a payback period of 1.6 years was determined.

While a complete database of autoclaves is not currently available, Michigan State University Capitol Asset Management does keep an inventory of equipment costing $5,000 or more. A list of autoclaves/sterilizers included in the inventory can be found in the appendix. Upon further research, it was found that the Biomedical Physical Sciences Building has at least 21 sterilizers that require a cold water line to temper the steam. All of these sterilizers are either of two Steris models listed in Table 10 (Kinkaid II, 2011).

Table 10: Autoclave/Sterilizer models found in Biomedical Physical Sciences Building.

Autoclave/Sterilizer Model
Steris 24X36X48" Prevac Sterilizer
Steris 20X20X38" Century Iso Sterilizer

The cold water line used to temper the steam from the sterilizer is controlled using a needle valve. A needle valve can be used to regulate the water's flow rate at relatively low flows. While there are various operational disadvantages to having a manual needle valve, the main problem with these valves is the constant use of water. The water lines used for tempering in the Biomedical Physical Sciences Building is a 1/8 inch pipe (Anderson, 2011). This size pipe generally allows for a 1 gallon per minute or 60 gallon per hour flow rate. This is the same flow rate used in the University of Michigan water conservation kit pilot study.

Because the amount of steam needed is extremely variable depending on the equipment being sterilized and the cycles chosen for sterilization, the cost analysis was based solely on water savings attributed to the water line used for tempering. Once again, the fixed orifice with solenoid valve was assumed to reduce water consumption to 23 gallons per hour.

$$60\,\frac{gallon}{hour} - 23\,\frac{gallon}{hour} = 37\,\frac{gallons}{hour}$$

$$37\,\frac{gallons}{hour} \times 24\,\frac{hour}{day} \times 365\,\frac{day}{year} = 324.12\,\frac{kilogallon}{year}$$

$$324.12\,\frac{kilogallon}{year} \times 3.81\,\frac{dollars}{kilogallon} = \$1{,}234.90\ per\ year$$

In addition to the kits reducing the average flow rate to 23 gallons per hour, the sterilizer can be scheduled to shut off every night when it is not in use. Assuming the units are only left on 18 hours a day, the above calculations were adjusted to account for the time where there is zero flow through the cold water line.

$$60\,\frac{gallon}{hour} - 0\,\frac{gallon}{hour} = 60\,\frac{gallons}{hour}$$

$$60\,\frac{gallons}{hour} \times 6\,\frac{hour}{day} \times 365\,\frac{day}{year} = 131.4\,\frac{kilogallon}{year}$$

$$37\,\frac{gallons}{hour} \times 18\,\frac{hour}{day} \times 365\,\frac{day}{year} = 243.09\,\frac{kilogallon}{year}$$

$$(131.4 + 243.09)\,\frac{kilogallon}{year} \times 3.81\,\frac{dollars}{kilogallon} = \$1{,}427\ per\ year$$

In conclusion, using a water conservation kit similar to that used in the University of Michigan pilot study would result in a cost savings of $1,427 per year per unit. With most water conservation kits ranging from $1,000 to $1,800 per unit (van Gelder, 2004), a payback period of

8 to 15 months is expected. Considering that the Biomedical Physical Sciences Building has 21 of these units, the building's water consumption could be reduced from 32,380 KGAL per year to 24,515 KGAL per year, nearly a 25% decrease.

This cost analysis is evidence of the need for a laboratory equipment database. Sterilizers vary immensely in size and design, making a campus wide cost analysis difficult. It is recommended that the following data is included in the sterilizer section of the future database:

- The presence of a cold water line to temper the steam.
- The size of the pipe for the cold water line.
- The size and type of the valve.
- Typical idle times for the sterilizing unit.
- The age and model of the sterilizing unit.
- The presence of any water conservation measures.

Once this data is known, priorities can be made for which buildings should install water conservation kits. While we know the Biomedical Physical Sciences Building has 21 of the type of sterilizers that should be retrofitted, this process has already been started. Currently five of the 21 sterilizers have a type of water conservation kit installed. All 21 are expected to be completed by February of 2012. Once the water meter data becomes available after the sterilizers have been retrofitted, it will be interesting to observe the water savings.

GENERAL FUND BUILDINGS: Water Purification

Many water purification methods consume water in the process of improving water quality. One of the methods that is commonly used at MSU is reverse osmosis. This process is often used to provide pure water throughout a particular building for research. Smaller units are also found in residence hall lobbies to provide high quality drinking water (to discourage use of bottled water).

Reverse osmosis is the process of applying pressure to water on one side of a selective membrane where water is allowed to pass through the membrane while most of the solutes cannot. The process is similar to simple filtration, however, reverse osmosis is driven by solute concentration, pressure, and the water flux rate. Filtration is primarily controlled by the size of the solute and the size of the pores in the membrane.

Because the effectiveness of the reverse osmosis membrane is dependent on the solute concentration gradient, the concentrated side of the membrane must constantly be diluted to maintain the desired water quality in the effluent. In other words, reverse osmosis does not remove the solute; it simply allocates a majority of the solute to a portion of the inlet water. This is the precise mechanism that causes reverse osmosis to be a water consuming process.

The ratio between the product water flow to the flow of the inlet water is called *recovery*. If a reverse osmosis system had a 50% recovery, half of the inlet water would become the product and the other half would be disposed of as it has a high concentration of ions found in the untreated water. This stream is called the concentrate or reject stream. There are a few methods for minimizing this wasted water: increase the recovery, find an alternative use for the concentrate, and to minimize the need for purified water.

As research in membrane technologies continues, it has become apparent that high percentages of recovery can be met. In fact, it is possible to reach such a high recovery that the concentrate is allowed to evaporate; this is called zero liquid discharge (Heijman, 2009). This method requires very successful pretreatment to remove water constituents that are prone to scaling the membrane. Improving the recovery of a system would take an extensive cost analysis project to determine the feasibility. Some of the factors to investigate when determining the cost effectiveness of improving the recovery are:

- The feed water chemistry given versus the product water chemistry required
- The cost of energy required to maintain pressure across the membrane
- The cost of energy required for pretreatment processes
- The cost of reagents required for pretreatment processes
- The cost of maintenance and upkeep
- The capitol cost of equipment required (i.e., a new reverse osmosis unit)

The Engineering Research Complex, like many laboratory housing facilities, has a building wide reverse osmosis unit. A summary of the processes in this system can be found in Appendix E. This unit has a recovery of approximately 60%. Assuming the system runs at feed flow rate of 1.25 gpm (varies depending on demand); the concentrate being wasted is 0.5 gpm. By increasing the recovery to 90%, 197.1 KGAL of water and $750 would be saved every year if the unit is left on 24 hours a day. This basic calculation shows how a payback period can be calculated once balanced with the various costs listed above. An extensive study would be required to balance water, energy, material, and capital costs with the required product water quality and quantity.

Rather than trying to improve the efficiency of the reverse osmosis unit itself, the concentrate could be used where high quality water is not necessary. Some examples of these uses are irrigation, make-up water for cooling towers, and flushing toilets in the facility. The actual wasted water from the reverse osmosis process would remain unchanged while the water needed for other applications would be decreased. There are no federal regulations for water reuse, but the state of Michigan requires any of these reuse projects to be approved by various state and county codes. Some of these regulations may require proper monitoring of the water quality.

Another method of decreasing the amount of reject water produced from reverse osmosis is to decrease the overall need for purified water. Having purified water available at the faucet often leads to excess use. Most laboratory activities do not need such a high quality of water. Instead, standard tap water could be used. Proper training of when purified water is needed, and when it is not, is an inexpensive method for decreasing the water consumption in laboratories. Awareness programs can be very effective at reminding the laboratory workers of the waste that can occur from misuse of purified water. Some simple recommendations of these programs include:

- Posters demonstrating the added water consumption resulting from water purification.
- “Why waste” stickers on faucets (much like the stickers on light switches).

- An additional segment of online training that describes the proper uses for purified water compared to tap water.

It is recommended that simple programs such as those listed above are initiated in laboratories across campus to promote water conservation. While water reuse is an assured method for reducing water consumption, it may also require monitoring to pass regulations and thus may be difficult to implement on a campus-wide scale. Also difficult, would be improvements to the recovery of reverse osmosis units on campus. A pilot study can be conducted to determine the payback period of these upgrades. However, the reverse osmosis units in different buildings are likely to vary in model and design. Because of this, a pilot study may reveal a favorable payback period but this value would not be applicable to all systems on campus. Including the building wide reverse osmosis units in the future laboratory equipment database may help determine where retrofits are appropriate.

GENERAL FUND BUILDINGS: Best Laboratory Practices

The US Environmental Protection Agency and the Department of Energy jointly issued a guide, Laboratories for the 21st Century that describes some of the best technologies that can be employed in laboratories to reduce water consumption (Tanner, 2005). These best laboratory practices are summarized in this report for insight as to where Michigan State University's laboratories could be improved.

Laboratory Cooling Towers

For laboratories that use cooling towers, this may be the best opportunity to conserve water. Cooling towers consume water in three different ways: evaporation, drift (or water droplets blown out of the tower from air flow), and bleed-off (which is used to remove the concentrated water resulting from evaporation). To account for all of these water losses, make-up water is constantly added to the system.

To conserve water, this make-up water needs to be minimized. One way to do that is to increase the cycles of concentration of water in the tower, or in other words, increase the concentration ratio (CR). The concentration ratio is related to how many times the water circulates through the tower before it is discharged. Simply put, the more the water is recycled in the tower, the less make-up water will have to be added. The following equations describe the concentration ratio:

(Eq. 1) $$CR = \frac{C_{Bleed}}{C_{in}}$$

(Eq. 2) $$CR = \frac{M_{Bleed}/V_{Bleed}}{M_{in}/V_{in}}$$

The term C_{Bleed} and C_{in} are the concentration of solids in the bleed and make-up stream, respectively. Knowing that concentration is the mass of the solid (M_{Bleed} or M_{in}) divided by the volume of the solution (V_{Bleed} or V_{in}), the equation can be expanded. Assuming that no fouling occurs and drift is minimal, the mass of solids entering are the same as that of the bleed. Also, the volume of water exiting the bleed is equal to the make-up volume after accounting for evaporation (V_{evap}).

(Eq. 3) $$V_{Bleed} = V_{in} - V_{evap}$$

(Eq. 4) $$CR = \frac{M_{in}/(V_{in} - V_{evap})}{M_{in}/V_{in}}$$

After rearranging equation (4), the effect of concentration ratio on water savings can be described by an equation that is independent of the mass of solids in the system.

(Eq. 5) $$V_{in} = \frac{V_{evap} \times CR}{CR - 1}$$

Using equation (5) that describes make-up water, a plot was created demonstrating the potential water savings. While this plot was determined assuming 2.8 gpm as the volumetric flow rate due to evaporation, the shape of the curve is the same at all evaporation rates. As shown in Figure 10, increasing the concentration ratio from 2 to 5 can have a dramatic impact on water savings, specifically, a 37.5% decrease in water use.

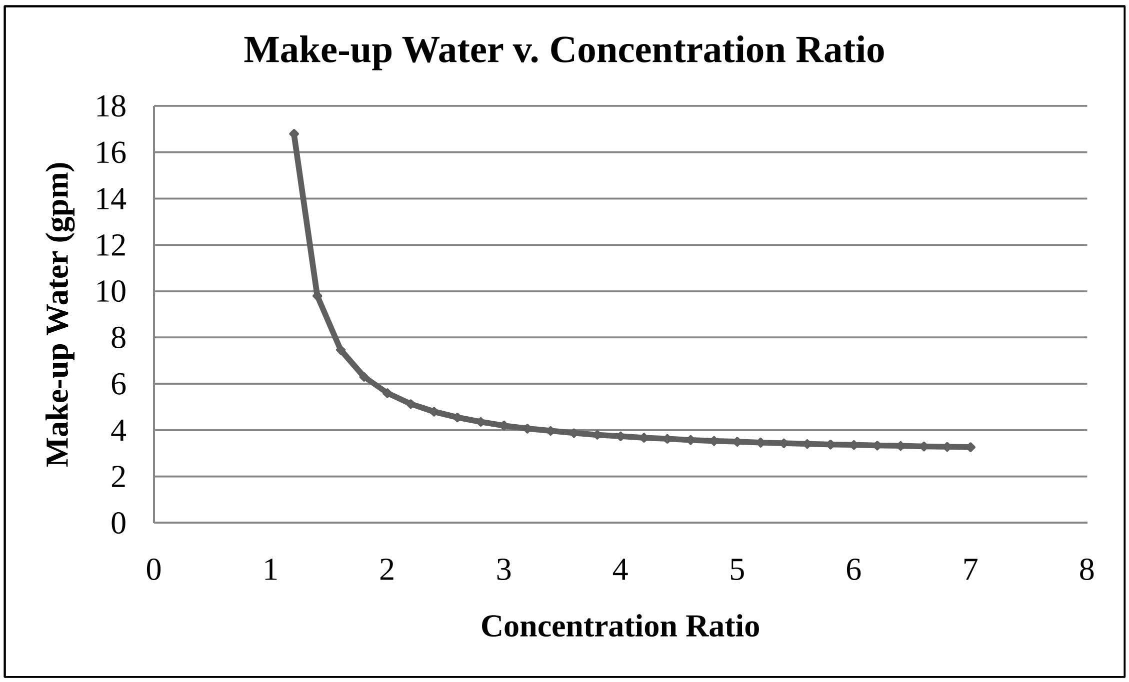

Figure 10: The effect of concentration ratio on laboratory cooling tower water consumption.

The drawback to increasing the concentration ratio is the increased likelihood of fouling. To balance the water savings with the fouling of the system, water chemistry monitoring would be necessary. By installing a conductivity meter (to measure conductivity which can be related to the total dissolved solids (TDS) using equation (6)) and a flow meter at both the make-up water and the bleed-off lines, one can ensure that excessive solids do not accumulate in the system.

(Eq. 6) $$TDS(mg/L) = Conductivity(\frac{\mu mho}{cm}) \times 0.65$$

Equation 6 is best used in a range of specific conductivities between 10 and 500 µmho/cm. The conductivity unit mho is the reciprocal to the unit ohm, a measure of resistance (Mackie, 2004).

Equipment Cooling

In laboratories which do not have the benefit of a cooling tower, a smaller cooling system is often used. One of the most wasteful uses of water in the laboratory is using single-pass cooling, rather than using a cooling loop. Single-pass cooling is often used because of its simplicity. If a piece of equipment requires cooling, a line is attached to the water supply and allowed to discharge directly into the sewer system after it passes through the equipment. Rather than simply running tap water to cool equipment, the water can be looped while using a small chiller to reject the heat. Another way to conserve water would be to use the discharged water from the single-pass cooling for other processes around the lab. Some laboratory equipment units that are often used in single-pass cooling are:

- Vacuum pumps
- Electron microscopes
- Mass spectrometers
- Ozone generators

Disinfection/Sterilization Systems

Sterilizers use water to create steam to disinfect various laboratory equipment/utensils. While the steam itself generally constitutes a minimal amount of water, the process can still be quite wasteful. To cool the steam to the required 140°C before it enters the sewer, a water line is often added to the steam to temper the discharge. This constant addition of water can waste large amounts of water. Some of the best laboratory practice tips for improving water efficiency in regards to sterilizers are:

- When purchasing equipment, consider only sterilizers designed to turn off the water line when it is not in use.
- Lower the flow rates to the minimum flow recommended by the manufacturer.
- Rather than using water to temper the steam, install an expansion tank, if it does not interfere with the manufacturer's specifications.
- Install a mechanism to automatically shut off the units when not in use.
- Use the steam condensate for other laboratory equipment (i.e., make up water for the cooling tower).
- Install a water conservation kit.

The last sterilizer water conservation tip was previously discussed in this report.

SUMMARY OF RECOMMENDATIONS

Plumbing Fixtures

After completing cost analyses on various plumbing fixtures, it is recommended that any remaining outdated fixtures be replaced with low flow fixtures. The outdated fixtures include tank-style urinals, 3.5 gpf toilets and 3.0 gpf urinals. It was shown that in high traffic buildings, the payback period for replacing these units with low flow and ultra-low flow units are all less than 5 years. Replacing low flow fixtures with ultra-low flow fixtures are currently yielding payback periods of over 10 years. As water prices continue to rise and the price of toilets/urinals decrease, that payback period will likely decrease as well.

Before a campus wide effort is enacted to replace all of the outdated fixtures, a single building trial run should be completed. The plumbing for most buildings on campus are designed for flow rates associated with 3 to 3.5 gpf fixtures. Switching to low flow fixtures may reduce the velocity in the pipe to the point where solids accumulate in sewer lines in the building. If the plumbing in the renovated building would need to be updated, this will significantly increase the payback period of replacing these fixtures. However, if there are already plans to update the plumbing, all piping should be designed to allow for low flow plumbing fixtures.

Laboratory Practices

The Environmental Protection Agency (EPA) and Department of Energy (DOE) have already recognized the waste of water resulting from outdated laboratory practices. In response to this, the EPA and DOE have released a publication to outline the best practices for water efficiency in multi-purpose laboratories. Some of the more important practices to look into, with regard to MSU laboratories, outlined in the publication are:

- Cooling Towers
- Equipment Cooling
- Disinfection/Sterilization Equipment

With such a clear correlation between General Fund Building water consumption and the presence of laboratories, it is recommended that a future study be focused on how laboratory best practices effect water consumption on a trial high-occupancy laboratory. Monitoring inlet and outlet water quality data for laboratory cooling towers will allow the concentration ratio to be optimized, and consequently the water consumption minimized.

Equipment cooling is very difficult to monitor because of it is up to the discretion of the lab worker to conserve the water. It may be beneficial to include an online training module that demonstrates how to use loop cooling rather than single-pass cooling. This could be included with the already required laboratory safety modules.

It is a misconception that sterilization equipment does not contribute significantly to water consumption. While smaller models only consume the steam required to sterilize the equipment, larger models often have a cold water line to temper the steam running 24 hours a day. These cold water lines used for this tempering can amount to 525 KGAL per year if a 1/8" pipe is used. Larger pipes consume a greater amount of water. A campus-wide cost analysis on sterilizing equipment would be difficult due to the complexities of sterilization equipment design and the varying use of the equipment. The laboratory equipment database, currently being created by Facilities Planning and Space Management, will be a great asset to prioritizing water conservation kit retrofits by quantifying which sterilizers require a cold water line for steam tempering.

Findings show a considerable benefit to implementing water conservation retrofit kits. Both a study conducted by a neighboring university and a cost-analysis on current Biomedical Physical Building sterilizers show a potential investment payback period of 2 years or less (Wells, 2011).

Water Supply

The investigation of water consuming equipment had revealed the need to conserve water in campus labratories. Similarly, the supply of water can be investigated to reduce wasted water on MSU's campus. It is believed that a closer investigation of building wide reverse osmosis units will result in the largest water savings in this area.

The easiest method of conserving reject water from reverse osmosis is implementing awareness programs to educate laboratory workers of the waste associated with misuse of purified water. The installations of wall posters and stickers on faucets will prompt the user to consider water conservation and training programs will instruct users as to the appropriate situations for using purified water.

Using the rejected water for other water consuming processes is also recommended. Because this may require water quality monitoring and significant design considerations, the opportune time to make this change would be during the construction of a new facility or during an extensive renovation.

Retrofitting reverse osmosis units has the potential to save significant amounts of water. However, the cost analysis for such an upgrade is fairly complicated and would likely require a pilot study to determine an accurate payback period. Smaller changes to the recovery may be achieved by proper water quality monitoring and adjustments to pretreatment processes.

Monitoring

Past and present research on MSU's water consumption could not be completed, to a great extent, without proper water meter data. The accuracy of cost analyses are only as accurate as that of the water data provided, making the water meter program at MSU very important. The recommendations involved with water monitoring are as follows:

- Continued observation of water meter data to identify changes in water usage and those buildings for which water usage is much greater than average.
- Further studies conducted to determine the reason(s) for current outliers, including VanHoosen and Mason/Abbot Halls.
- Investigation of future Biomedical Physical Sciences Building water consumption in order to quantify the water savings associated with the 21 sterilizer water conservation retrofits.

- Investigation of future Emmons Hall water consumption to determine the magnitude of water savings associated with numerous small scale changes being made in the newly renovated facility.
- Investigation of future Brody Square water consumption to aid in recommendations for future cafeteria renovations. The magnitude of water savings associated with rain water collection and the food pulper/extractor are two focuses of this recommendation.
- Implementation of water quality/quantity monitoring for a trial run involving the adjustment of the concentration ratio in a laboratory cooling tower. Finding the correct concentration ratio to minimize water consumption without causing fouling and confirming the water savings will aid in prioritizing laboratory best practices.

FUTURE OPPORTUNITIES: WILSON HALL

Also included in this report is a discussion of the creation of a sustainable floor in the Wilson Hall Residence Hall. Wilson Hall is the home to the Engineering Residential Experience where students considering engineering as a major can live in a community with more resources catered to their engineering interests. Recently the project staff was asked by Professor Udpa, Dean, College of Engineering, to develop the concept of sustainability as a theme for one floor in the engineering residence hall, Wilson Hall. Wilson Hall already has 2 themed floors, Energy and Transportation. With a huge interest in sustainability, recycling, and "going green" from the students and faculty, a sustainable floor could be very successful. Because of the direct relevance to improving campus sustainability, these recommendations are also discussed in this report.

To create a sustainable floor in Wilson Hall for the Engineering Residential Experience all aspects of sustainable engineering should be considered, the efforts should not just be limited to water consumption. Both policy changes and building renovations can help achieve a more sustainable living environment for the resident students, thus the recommendations in this report are divided into these two categories. Bailey Hall, which has been renovated to meet LEED-Silver Standards, will become the residential hall for the Residential Initiative on the Study of the Environment (RISE). As this hall will have a sustainability focus, further investigation of a sustainability-themed floor in Wilson should include benchmarking against Bailey Hall efforts.

Policy Changes

Seminars

As part of the Engineering Residential Experience two classes are required to satisfy the academic part of the program; Introduction to Engineering Design and Introduction to Engineering Modeling. For students interested in living on the sustainable floor, a series of seminars may be helpful to promote green living. Another option is to have a separate section of Introduction to Engineering Design that focuses on sustainability. Rather than projects such as designing an edible car, students might be able to determine an obstacle to sustainability and design an object to overcome it. By showing students the repercussions of not keeping sustainability in mind (e.g., the need for a new power plant) and demonstrating how simple things like turning off electronics can help MSU's campus, the students will see that we do take "being green" seriously at MSU. If successful, students will carry these habits long after graduating from their program.

Sparty's

The campus-operated retail convenience store, Sparty's, has a location in Wilson Hall. These small stores are already helping the push towards a green campus by using discounts to encourage customers to bring their own mugs. However, further improvements can be made to promote a more sustainable living environment.

Students tend to choose bottle water for one of two reasons: convenience and perception of poor water quality due to the hardness of the water purveyed on campus. However, there may be ways to reduce the sales of bottled water, beyond those already attempted. Students with the Combox-change meal option are able to choose a beverage, entrée, and a snack as part of a meal. Many students choose bottled water as their beverage of choice. One idea to limit this is to start a promotion where students can choose an extra snack if they bring their own reusable water bottles for water or a fountain drink. This will limit the waste of water bottles as well as the plastic cups used for fountain drinks.

Another way to discourage bottled water use is to provide high quality water to the residents. Currently the residence halls have softening (membrane filtration) units on the first floor for student use. It may be worth looking into conducting a sociology study, perhaps as an Honors College seminar, to determine the actual use of these softening units, along with obstacles to their use. As part of this effort, methods to promote students to using the softened water, rather than bottled water, could be investigated.

Recycling

With so many students living in the residential facilities, promoting recycling efforts is a sure way to decrease waste in the building. Posters are already displayed in the hallways of Wilson to direct students to use the recycling bins on the first floor. Standard trash goes to the compactor through chutes on each floor. This arrangement makes it convenient for students to throw away recyclables with their trash. By placing a recycling area in the lobby on every floor, students will be more inclined to recycle their waste material. Custodial services or volunteers from the sustainable floor could be responsible for taking the bins on each floor to the main recycling area on the first floor

Renovations

Toilets

It is our understanding that the toilets in Wilson Hall are still 3.5 gallon per flush (gpf). These toilets are outdated and a significant amount of water can be saved if these toilets are replaced with 1.6 gpf ones. A physical inspection of the bathrooms in the rooms will be necessary to confirm what toilets are currently installed. In 1995, the National Energy Policy Act mandated that all new toilets must use no more than 1.6 gpf. Therefore, if the Wilson Hall bathrooms are renovated, the new toilets would be required to be 1.6 gpf or less. While that is a significant water savings, a sustainable engineering floor should achieve much more.

Dual flush toilets have been around since the 1980s but were significantly improved in the 1990's. The idea for the technology is quite simple, a separate button to flush solids and liquids. Because much less water is needed to flush liquids, large water savings can be observed. The solid flush will use the standard 1.6 gpf while the liquid button will only use 0.8 gpf. With similar installation, only slightly higher unit cost, and up to 67% water savings (Green Building Supplies, 2011), dual flush toilets could make for a cost worthy renovation on the sustainable floor.

Window Replacements

Another emergent technology in the building retrofit industry is that of passive dynamic glazing. Passive dynamic glazing for a window simply means that it is able to change its physical properties under the influence of visual, thermal, or infrared transmissions. This technology is similar to that of transition lenses. When the sun is shining on the window, it will change its properties to block out the heat. In 2003, it was found by an ASHRAE study that low emissivity glass saves buildings 8-15% on annual energy costs, while dynamic glazed windows can save up to an additional 19% (Tinianov, 2011). Passive dynamic glazing would be a unique addition to the sustainability floor, increasing the environmental atmosphere while improving Wilson Hall's energy usage.

Solar Thermal / Photovoltaic

A more extensive addition to a sustainable floor would be the use of solar thermal or photovoltaic cells. These two technologies look similar but have two different mechanics. Solar thermal takes the energy from the sun and converts it to heat (usually by heating up water to provide hot water or heated floors) while photovoltaic takes the sun's energy and converts it to electricity. While it is possible to have these cover the building wall on the sustainable floor, it would like be more effective and easier to install on the roof of the building.

Rain Water Collection

Rain water collection is by no means a new technology, but it is an excellent and low-cost way to save water. While more information will be needed to understand the possibility of using this system at Wilson Hall, generally rain water collection consists of directing rain water from the roof of a building to a cistern. Some systems can actually produce and store potable water, while most use the rain water for irrigation. A great use for this rain water is being tested at the new Brody cafeteria, where they are using rain water to flush the toilets in the main floor restrooms.

Green Roof

A green roof, while very aesthetically pleasing, also provides great insulation for a building and reduces peak flows for storm water systems. The limiting factor for the installation of a green roof onto an existing building is the strength of the roof. In general, a green roof will add 5-6 lbs per square foot for every inch of media added to the roof (Rowe, 2011). To grow grasses or other perennials, 9-14 inches of media will be required. However, to grow shallow sedum plants like that cultivated on the Plant and Soil Sciences Building green roof, as little as 2 inches will be required. The Physical Plant staff will need to be contacted to determine if the structural integrity of Wilson Hall's roof is sufficient for 2 inches of media.

APPENDICES

Appendix A

Water Meter Data (KGAL/month)

Table 11: Water Meter Data (KGAL/month)

Building	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BERKEY HALL 0002	2004							36	43.2	112.6	120	91.76	55.03
	2005	91.4	91.22	81.6	95.9	33.3	34.4	34.2	55.53	105.8	104	78.49	55.87
	2006	87	100	76	102	44	38	49	67	149	127	92	57
	2007	107	99	83	102	59	48	50	7	13.6	11.7	78.88	77.25
	2008	57.9	126.53	86.5	84.56	73.5	42.3	57.3	55.85	117.5	153	118.48	80.25
	2009	67	121.51	89.6	105.4	152	64.7	72.1	56.99	111.8	185	101.84	89.99
	2010	75.4	108.37	91.8	142.1	73.5	71.6	81	71	115	23	19	11
	2011	12	23	16	15	5	0						
OLIN MEMORIAL HEALTH CENTER 0003	2004							111	116	131	115	90	94
	2005	109	92	77	83	81	566	408	188	159	146	109	152
	2006	94	94	88	121	103	144	220	194	166	151	93	67
	2007	79	81	87	117	113	142	128	192	169	150	78	99
	2008	98	163	96	158	151	162	165	214	132	153	95	71
	2009	62	91	88	84	120	83	129	107	105	152	80	88
	2010	56	118	79	133	89	150	195	177	110	176	168	123
	2011	22	71	32	69	103	153						
HUMAN ECOLOGY 0005	2004							16.3	21.2	40.7	41.4	36.9	22.1
	2005	35.4	37.2	33.5	40.5	25.9	20.5	23.7	21	58.8	36	26	21
	2006	25.6	31.7	28.6	50	46	55.9	92.3	90.6	67.5	58.2	36.4	25.3
	2007	42.2	41.1	35.6	49.1	34.6	36	43	45	49.3	42.3	29.1	32.8
	2008	20.3	417.4	160	43.8	45.6	21.4	32.7	31.1	56.3	56.3	56.4	39.4
	2009	23.4	46.8	46.9	46.9	46.9	16.6	18.4	13.7	30.5	22.7	73.6	41.8
	2010	22	44.1	34.5	58.6	32.5	17.9	15	16	27	33	27	37

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2011	31	39	48	31	32	14						
UNION BUILDING 0006	2004							497	436	486	424	194	175
	2005	179	220	198	456	395	729	810	730	730	643	447	458
	2006	395	451	473	699	668	719	829	756	762	546	413	328
	2007	167	203	187	290	311	355	349	422	384	326	120	135
	2008	63	177	111	182	205	355	301	400	321	366	184	100
	2009	82	165	119	146	373	220	388	274	300	300	200	100
	2010	100	100	100	230	370	220	764	556	300	249	85	109
	2011	134	183	60	129	175	359						
MUSEUM 0013	2004							124	205.4	109.2	172	123.76	0
	2005	196	122.99	137	147.1	144	122	105	99	134.8	103	28.02	0.47
	2006	0	0	0	0	0	0	0	0	0	0	0	0
	2007	0	0.04	0	0.01		0	0	0	0.03	0	0	0
	2008	12.3	16.2	11.8	15.3	10.5	9.7	13.1	9.4	33.5	13.3	9.3	7.1
	2009	12.9	11.3	11.3	15.4	12.8	12	10.2	8.5	8.9	26.5	15.2	8.4
	2010	11.4	11	11	12	14	12	11	10	9	17	12	9
	2011	22	16	14	38	14	16						
NATURAL SCIENCE 0024	2004							397	373	382	426	353	222
	2005	283	259	291	355	299	411	458	464	394	304	195	121
	2006	160	159	154	275	210	241	499	487	398	192	145	91
	2007	127	127	167	264	344	413	373	403	310	255	134	108
	2008	95	157	129	151	222	371	457	692	461	486	279	198
	2009	177	238	193	230	402	368	632	565	488	511	289	307
	2010	211	282	246	462	384	533	833	799	430	527	455	170
	2011	272	262	251	633	543	846						
PSYCHOLOG	2004							0		0	0	0	0

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Y BUILDING 0027	2005	23	49	48.2	55.1	33.4	59.3	67.3	37.1	63.6	65.4	43.8	37.2
	2006	44.5	49.8	41	49.6	30.1	30	29.1	30.1	62.2	145	46.6	41
	2007	51.4	54	43.4	122.5	122	94.4	29.7	36.4	57.6	58.2	39.9	41.9
	2008	27.7	65	45	51.1	53.8	39.5	29.8	35.2	48.9	64.8	26.2	64
	2009	30.3	75.7	45	48.4	63.9	44.5	41.8	31.7	52.1	72.9	61	46.6
	2010	29.9	38.5	64.4	70.6	40	35	43	41	51	61	64	38
	2011	74	64	77	39	36	35						
GILTNER HALL 0028	2007										0	0	0
	2008	0	0	0	0	0	0	0	0	0	0	0	0
	2009	0	0	0	0	0	0	0	0	0	0	0	0
	2010	78	79	92	146	120	119	186	113	111	266	119	72
	2011	147	71	61	200	182	144						
	2007											0	8.4
	2008	5.4	12.8	19.5	9.4	10.3	7.7	2.1	0	0	0	0	0
	2009	0	0	0	0	0	0	0	0	0	0	0	13
	2010	8	10	12	31	4	7	6	6	10	8	8	9
	2011	12	11	11	6	8	8						
	2009												0
	2010	130	997	471	631	881	515	924	508	551	519	431	440
	2011	399	405	319	415	347	792						
KEDZIE HALL (NORTH AND SOUTH) 0029	2004							191	190.8	188.9	184	187.9	97.5
	2005	110	116.1	164	167.4	211	310	349	406.6	268	262	156.1	133.5
	2006	58.2	51.7	46.4	51.9	25.8	29.4	28.3	25.7	70.3	69.6	51.5	30
	2007	52.9	50.6	68.4	98.9	22.3	26.4	22.1	99.5	280.5	324	454.6	340.5
	2008	361	238.9	302	383.3	347	103	67.2	79.9	94.7	65.1	47.6	61.4
	2009	108	111.3	102	79.9	19.6	2.8	9	9.7	50	68.2	48.2	15.1

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2010	45.7	50.1	102	98.6	14.1	22.3	16	4	1	2	1	2
	2011	2	2	2	2	15	30						
COMPUTER CENTER 0035	2004							50.7	72.65	89.19	97.4	86.41	62.58
	2005	81.7	73.2	86.2	76.43	68.2	92.6	30	69	106.2	102	60.63	59.48
	2006	81	74	74	76	62	62	65.1	56.9	114.1	93.9	75	54
	2007	76	71	69	75	51	57	78.6	78.61	78.62	89	97.01	37.41
	2008	84	56.4	63.9	72.62	51.7	49	58	53.37	107.2	74.5	59.75	50.07
	2009	65.9	65.55	28.7	108.8	42.2	60.3	45.9	43.6	46.93	127	64.74	32.82
	2010	58.2	57.51	66.3	55.58	39.5	53.2	44	36	39	34	39	174
	2011	61	50	65	56	53	40						
KELLOGG CENTER 0055	2004							1220	726	565	756	546	410
	2005	386	424	406	502	414	385	390	350	341	451	354	217
	2006	341	379	476	463	448	594	532	489	697	623	407	745
	2007	196	354	354	354	610	515	383	323	381	564	495	164
	2008	462	354	354	354	610	515	383	323	381	564	495	164
	2009	450	350	350	574	457	673	521	525	536	854	761	405
	2010	428	481	670	609	306	446	370	383	494	800	783	624
	2011	338	370	325	337	394	359						
	2004							2285	2460	1924	2332	1866	1789
	2005	2067	2108	2285	2495	2625	2667	2950	2594	2724	3691	3759	3167
	2006	3338	3265	3728	3922	3633	4144	4653	3876	4546	3361	5289	5055
	2007	3792	5941	1917	5364	5094	4949	5044	5687	4596	5066	5906	4085
	2008	5073	4190	4246	5301	4628	4210	5761	4001	5097	3617	2073	1737
	2009	1523	1435	2121	2785	2164	3273	2394	2547	2560	2967	2424	1557
	2010	1788	1716	2431	2700	2956	3000	2000	2500	2500	3000	2400	1786
	2011	1319	1960	950	880	1770	1340						

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
JENISON FIELDHOUSE 0056	2004							89	75	138	164	181	87
	2005	140	187	202	208	68	68	157	93	180	203	155	92
	2006	180	160	200	200	80	45	95	90	250	210	250	100
	2007	190	160	210	380	70	320	100	110	293	217	200	203
	2008	203	222	372	337	200	118	117	156	257	290	300	458
	2009	356	205	250	258	74	130	251	431	428	152	235	73
	2010	250	293	330	215	119	218	111	110	392	242	74	157
	2011	301	365	377	319	93	85						
SPARTAN STADIUM 0058	2005								0	640	497	192	88
	2006	45	45	49	261	287	249	464	1981	3588	1385	267	34
	2007	44	46	54	151	48	186	288	1926	4129	3675	1385	49
	2008	71	54	322	106	262	120	750	1460	4334	3222	849	83
	2009	51	59	48	376	68	3254	2964	3453	4275	3777	1691	60
	2010	95	90	88	125	71	173	356	450	3170	4995	57	68
	2011	125	180	142	123	4180	2793						
MUNN, CLARENCE L., ICE ARENA 0059	2004							237	234.8	218.7	293	241.8	165.9
	2005	232	239.7	222	199.4	133	213	276	234.4	226	259	276.4	149.3
	2006	235	190.4	275	325.1	103	270	313	271.9	277.1	248	176	446
	2007	202	193.5	176	114.9	123	235	206	205.6	220	317	292.3	172.7
	2008	423	191.4	195	157.8	342	218	306	222.6	346.6	233	153.9	256.5
	2009	223	275.1	150	157	74.6	323	260	240.2	285	304	286.5	333.5
	2010	316	203.4	305	281.2	131	401	387	374	252	534	335	274
	2011	284	284	284	284	284	284						
CENTRAL SERVICES BUILDING	2004							4	4.4	3.6	31.8	3.4	2.7
	2005	1	5.9	4.6	3.7	7.3	0.9	2.3	2.9	3.7	3.9	2.5	2.8
	2006	3.3	3.7	3.5	4.1	3.2	3.1	3.4	3.2	4.5	4	8.6	3

Table 11 (cont'd)

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0060	2007	3.9	3.9	5.2	5.1	3.4	5.5	4.2	4.5	4.4	4.6	4.7	2.1
	2008	4.6	13.7	4	4.1	3.7	3.1	6	5	4.8	4	3.2	2.7
	2009	3.6	4.1	3.4	3.8	2.9	4.2	3.1	3.4	3.8	3.2	3.3	2
	2010	3.8	4	4.9	4	3.4	12.3	4	3	4	5	4	4
	2011	16	4	6	2	5	3						
	2004							2.36	2.64	2.14	2.73	2.22	1.53
	2005	2.03	2.09	2.19	2.1	2.06	1.9	2.13	1.87	3.07	3.07	1.98	1.88
	2006	2	3	2	3	2	2	2	2	3	3	2	1
	2007	3	1	3	2	2	2	2	2	2	3	3	1.49
	2008	2.61	2.1	1.87	1.93	2.3	1.82	2.4	1.51	3.05	2.27	2.13	2.13
	2009	2.13	2.13	2.13	2.8	1.2	3.82	2.57	2.07	2.2	3.14	2.03	1.3
	2010	2.12	1.86	2.51	1.69	2.19	2.87	2	2	2	0	1	2
	2011	7	2	2	2	2	1						
LAUNDRY BUILDING 0068	2004							515	602	473	604	436	411
	2005	520	641	543	555	591	615	660	746	495	701	509	494
	2006	589	846	600	645	545	606	585	774	691	642	531	532
	2007	530	667	533	505	608	577	386	626	553	433	460	366
	2008	449	635	502	546	651	753	539	743	589	771	462	409
	2009	432	591	503	446	603	464	553	457	458	698	423	399
	2010	535	518	489	815	627	535	633	489	460	347	475	312
	2011	365	635	568	523	795	620						
BRESLIN, JACK, STUDENT EVENTS CENTER	2004							341	263.7	322	322	441	323.9
	2005	404	388.7	611	188.9	435	546	659	467.3	558.8	386	348	356.6
	2006	464	464.8	465	155.5	383	546	621	182.4	391.1	595	586.9	364.5
	2007	257	421.9	530	144.5	477	682	887	276.9	245.6	514	508	352
	2008	524	267.4	368	616.5	230	104	146	200	250	500	500	400

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0069	2009	353	289	424	243.2	214	428	59.4	60.2	169.5	327	402.2	250.4
	2010	307	284.5	610	525.8	443	620	327	284	154	440	357	383
	2011	199	120	126	585	436	638						
BUSINESS COLLEGE COMPLEX (EPPLEY) 0080	2004							43	107	34	188	85	56
	2005	79	86	84	162	140	60	78	93	101	128	94	73
	2006	67	141	70	102	51	71	88	64	123	115	84	73
	2007	110	122	92	116	53	79	51	67	116	127	135	40
	2008	128	92	104	102	50	85	59	87	130	117	79	43
	2009	103	98	111	110	52	66	47	88	126	92	112	42
	2010	109	112	152	88	61	169	60	71	81	152	80	72
	2011	110	86	97	84	70	49						
ENGINEERING BUILDING 0081	2004							51	17	50	47	41	40
	2005	41	57	53	56	40	48	39	50	63	54	38	52
	2006	46	37	40	44	27	48	44	59	57	67	102	41
	2007	30	51	53	60	58	75	25	48	63	107	58	73
	2008	59	59	196	75	35	27	48	86	71	79	85	29
	2009	42	158	48	96	85	42	52	31	44	146	117	30
	2010	288	107	94	145	71	69	85	164	144	178	116	161
	2011	36	43	188	59	50	81						
	2004							1790	1604	1248	406	237	171
	2005	178	279	255	372	491	1484	1761	1365	1248	603	187	320
	2006	186	228	250	574	495	933	1644	1043	706	438	235	163
	2007	174	282	208	355	655	1174	827	1174	942	496	242	129
	2008	164	298	174	322	403	817	880	1239	705	467	170	124
	2009	141	251	210	239	697	526	949	814	764	472	165	105
	2010	345	229	186	466	615	787	1195	167	2064	455	208	227

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2011	112	126	455	222	406	1086						
MSU COLLEGE OF LAW 0083	2004							53.5	118.2	174.4	181	198.3	129
	2005	134	192.9	180	183.3	109	89.1	60	50.3	189.5	224	186.7	135.2
	2006	237	121.7	162	250	102	95.6	92.5	84.7	223.4	253	182.9	259.9
	2007	175	212.8	167	261	123	105	70.1	88.4	218.8	277	293.1	113.2
	2008	242	181	236	267.7	124	131	138	181.4	336.8	267	209.4	82.3
	2009	262	159.9	240	313.3	134	40	172	158	200	250	200	241
	2010	197	282	270	293	160	121	198	251	349	369	296	216
	2011	204	264	280	319	235	236						
COMMUNICATION ARTS & SCIENCES BUILDING 0084	2004							68	75	112	110	96	72
	2005	97	120	98	109	65	68	72	78	130	130	95	178
	2006	105	115	114	126	65	91	119	97	135	151	123	88
	2007	118	152	123	145	79	78	55	113	137	128	200	88
	2008	93	68	86	125	96	90	68	131	141	176	114	77
	2009	105	132	106	129	154	106	185	415	434	699	358	69
	2010	704	145	143	282	219	278	479	301	1036	86	109	383
	2011	171	149	240	245	201	472						
PLANT & SOIL SCIENCES BUILDING 0086	2004							4689	4432	5113	6212	5222	3345
	2005	3473	2985	3198	3627	5173	5371	6102	4585	4611	4636	3829	3319
	2006	2261	2148	2551	5183	6638	6638	6638	5233	5632	5877	3836	2937
	2007	2547	2806	3047	3984	5252	3907	1410	1839	2847	2660	2384	1836
	2008	1651	2005	1651	2246	3726	3523	3718	4786	4021	3853	2698	1713
	2009	2394	2783	2979	2470	3823	2278	2592	2614	2356	2894	1668	1675
	2010	3302	1768	1800	1596	1534	2167	2000	2043	769	1997	1553	937
	2011	647	58	2039	2089	1832	3270						
PUBLIC	2004							41.3	48.8	48.2	53	48.1	40.5

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SAFETY 0087	2005	44.9	50.6	44.3	41	41	39.6	41.9	47.3	54	71.4	63.3	68.5
	2006	69.1	76	95.3	69.2	38.6	76.8	76.8	70.3	75.7	95.5	58.6	40.9
	2007	37.2	52.2	64.2	88.2	97	112	104	78.1	90.4	121	137.5	127.2
	2008	125	133.9	43	45.3	50.5	40.1	33.5	47.7	48.1	72.3	46.5	41
	2009	74.3	19.2	42.4	43.9	60	33.9	48.4	41.6	46.1	62.3	44.9	41.1
	2010	49.7	42.6	44.3	63.5	124	124	124	124	124	124	90	99
	2011	73	49	48	253	133	104						
MICHIGAN STATE POLICE	2010	0	116	111	97	78.7	78.7	156	110	110	111	59	59
	2011	31	29	28	38	48	118						
NISBET, STEVEN S., BUILDING 0128	2004							49.8	57.4	50.8	60	39.9	39.8
	2005	44.7	47.2	40	41.7	41.8	56.5	66.7	75	57.1	62.1	43.5	44.1
	2006	44.8	35.4	48.4	48.8	47.4	116	73.5	82.6	76.4	56.5	48.8	41.1
	2007	40.1	45.2	47.4	49.5	74.4	90.7	88.4	130.2	92.5	94.5	80.9	64.7
	2008	67.1	76.6	58.4	90.2	116	91.2	81.2	86.5	76.5	91.9	53.1	54.8
	2009	77.1	77.3	82	73.9	107	69.8	96.1	72.8	66.6	102	54.7	49.9
	2010	92.4	63.2	60.3	75.4	56.2	44.1	45	27	46	57	31	55
	2011	467	73	57	326	126	196						
ANTHONY HALL 0132	2004							9	19	3	0	0	0
	2005	0	0	0	2	2	23	1	19	4	12	0	0
	2006	0	0	0	1	0	7	4	7	0	4	0	0
	2007	0	1	1	93	561	831	869	1185	825	396	0	0
	2008	0	1	0	163	353	738	921	1005	659	209	0	0
	2009	1	0	0	21	490	698	1220	1038	708	78	0	0
	2010	0	0	1	102	489	1050	1501	1267	1054	173	1	0
	2011	1	1	0	37	298	964						
	2004							113	108.6	98.35	51.4	52.44	52.65

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2005	15.2	15.38	129	42.17	95.1	145	175	145.6	100.7	35.9	11.75	12.13
	2006	15.8	14.97	18.4	43.66	44.5	110	145	124.3	59.92	30.1	16.95	19.73
	2007	18.3	22.54	24.9	34.52	62.3	88.2	82.2	104.6	90.07	54	12.74	9.23
	2008	14.4	18.78	11.9	22.44	39.7	70.1	81.7	106	61.54	33	13.89	16.76
	2009	22	23.19	19.5	27.39	56	66.3	115	85.29	62.93	32.6	14.36	15.11
	2010	31.7	19.92	18.2	32.49	50.7	80.5	111	106	105	25	9	20
	2011	1	8	30	18	36	89						
	2004							1113	1058	1125	732	557	2013
	2005	2007	1403	1079	1181	1555	2421	3419	2795	1508	1280	810	771
	2006	698	525	498	566	442	846	1311	1624	2169	1542	246	297
	2007	234	173	503	257	250	1021	569	820	858	395	469	313
	2008	200	266	237	345	347	304	325	528	480	425	240	148
	2009	129	162	160	183	229	115	183	180	291	176	297	139
	2010	86	81	181	239	160	199	287	273	369	1400	2094	1820
	2011	2065	2152	1140	644	596	3189						
	2004							0	0	0	0	0	0
	2005	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	0	0	0	0	0	0
	2007	0	0	0	0	0	0	0	0.01	0	0	0	0
	2008	0	0	0	0	0	0	0	0	0	0	0	0
	2009	0	0	0	0	0	0	0	0	0	0	0	0
	2010	0.01	0	0	0	0	0	0	0	0	0	0	0
	2011	0	0	0	0	0	0						
USDA AVIAN DISEASE & ONCOLOGY	2010	16.1	5.98	0.36	2.85	2.29	3.41	3	3	0	2	3	3
	2011	3	2	2	3	4	3						
	2010	0	111.26	94	111.5	111	139	134	151	91	115	110	103

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LABORATORY 0143	2011	105	92	126	121	173	125						
MANLY MILES BUILDING 0154	2004							0	0	73.8	27.5	20.2	19.9
	2005	24.6	25.6	23.6	23.55	25.8	27.5	26.1	26.5	22.2	23.8	19.3	22.5
	2006	24.6	17.3	23.2	22.8	18.1	23	18.2	24.6	22.5	23	22.3	43.9
	2007	21.7	47.5	28.3	25.5	28	25	21.2	28.9	25.1	28.1	27.5	25.7
	2008	23.5	36.9	31.5	30.7	41.7	29.3	25	37.5	38.1	36.7	25.6	26.5
	2009	34.2	34.9	27.6	26.9	37.7	32.2	37.1	31.3	29.4	45.3	24.2	23.3
	2010	39.7	32.5	35.1	36.7	30.2	30.4	33	21	44	42	19	30
	2011	28	32	25	38	25	36						
GEAGLEY LABORATORY 0156	2010	498	403	427	437	444	320	476	561	363	441	390	336
	2011	74	127	83	224	444	135						
BIOMEDICAL PHYSICAL SCIENCES BUILDING 0160	2004							4030	4250	3260	2030	940	860
	2005	1070	940	950	1910	2510	4250	4830	4850	3410	2340	1090	1310
	2006	1060	1180	880	1830	2550	3510	5750	4450	3050	1570	1190	1460
	2007	1310	1260	1410	1680	3170	4440	4110	4870	3680	2550	1260	1370
	2008	1330	930	1000	2160	3040	3640	5900	3230	3500	2500	1200	1200
	2009	1200	1000	1000	2000	3000	3500	0	0	0	0	0	0
	2010	0	250	1950	1830	3270	5280	6390	6100	2490	1600	1440	1670
	2011	250	2730	2020	1140	4630	4190						
CHEMISTRY 0163	2007											0	
	2008	0	1	39	49	39	39	40	41	55	49	36	32
	2009	49	46	43	58	49	50	21	15	28	37	52	21
	2010	47	43	76	54	43	50	47	50	50	90	61	51
	2011	47	100	76	95	60	50						
PHYSICAL	2010					0	35.3	72	38	33	28	24	25

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PLANT SHOPS & OFFICE BUILDING 0167	2011	25	22	27	31	39	42						
FOOD STORES 0171	2004							5	11	14	13	8	11
	2005	15	12	10	13	11	9	20	21	15	17.9	17.9	17.8
	2006	17.9	17.9	17.9	17.9	17.8	17.9	36	36	36	36	36	36
	2007	36	36	36	36	36	36	38	70.1	69.2	72.1	66.8	43.7
	2008	52.6	87.8	55.2	64.3	60.5	38.4	33.3	60.1	61.1	84.7	58.3	40.1
	2009	57.6	67.6	56.2	63.3	40	35	35	50	50	65	56	40
	2010	47	47	50	60	40	41	37	43	51	54	49	35
	2011	80	56	60	60	48	67						
INTRAMURAL RECREATIVE SPORTS EAST 0175	2004							68.9	55.7	80.3	90.6	71.9	37.8
	2005	77.7	123.7	45.1	13.7	7.5	4.8	5.1	9.8	5.1	1.5	1	0.9
	2006	0.1	0	0.3	0	0.1	0.9	0.7	0.1	0.4	0.4	0.4	0.3
	2007	0.5	0.5	0.2	0.4	0.1	0.5	0.5	0.3	0.4	0.2	0	0
	2008	0.2	0.1	0.1	0	0	0	0	0.1	0.1	0	0	4.2
	2009	0	0	0	0	0	0	0	0	0	0	0	0
	2010	0	0	0	0	0		3	3	4	3	3	2
	2011	4	4	6	4	2	2						
PACKAGING 0177	2005				33.2	65.9	44.3	56.5	61.3	69.6	56.2	40.4	48.8
	2006	28.7	39.5	57.7	48.6	65	39.1	64.9	56.4	49.6	50.5	33.8	30.5
	2007	31.7	77	37.8	33.2	31.3	30.8	37.3	41.4	46.3	61.7	50	49.2
	2008	18.9	27.6	34.6	43.4	23.1	29.3	19.8	40	33.1	41.5	24	40
	2009	64.7	51.3	43.7	40.7	32.4	17.4	25.7	30.7	37	112	43.3	33.1
	2010	27.1	93.4	40.4	42.3	19	64.5	30	36	54	49	30	28
	2011	13	13	82	35	47	3						

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PLANT BIOLOGY LABORATORIES 0178	2004							99.4	118.5	132.7	74.4	83.9	101.1
	2005	104	93.3	105	124.2	148	119	175	155.3	164.7	133	96.9	56.9
	2006	132	44.4	68.1	82.1	122	166	210	241	158.3	103	88.2	76.8
	2007	51.7	50.9	84.7	63	124	207	192	192.2	97.4	77.2	46.4	38.6
	2008	30.2	99.5	103	123.2	77.4	100	181	113.3	111.2	44.6	14	5.8
	2009	10.8	20.8	50.1	47.3	88.9	23.8	13	14.9	12.2	38.6	6	9.9
	2010	20.6	12.3	10.8	33.7	14.9	11.4	23	23	14	15	26	27
	2011	20	12	10	30	15	10						
	2004							383	462	454	409	370	306
	2005	410	440	468	1385	825	474	1915	443	548	455	372	431
	2006	384	426	462	489	449	605	498	770	661	697	629	598
	2007	518	533	662	600	665	686	577	737	722	728	663	587
	2008	585	724	579	685	955	860	930	1124	945	1019	788	1093
	2009	3144	734	719	691	969	713	1007	796	756	1013	521	999
	2010	699	689	682	888	739	773	868	871	1037	903	509	605
	2011	507	557	714	462	148	925						
	2004							334	388.2	330.1	329	284.9	264.5
	2005	292	365.1	245	269.7	433	282	354	339.3	296.1	303	234.5	289.4
	2006	257	230.4	285	300.1	254	309	315	338.5	247.4	328	209.7	139.2
	2007	119	139	121	165.7	184	155	117	140.5	142.8	119	108.8	51.5
	2008	82.3	122.8	153	373.3	359	89.3	105	129.8	157.1	146	123.1	191.5
	2009	389	456.2	521	525.7	756	564	576	471.1	481.7	458	241	300.7
	2010	464	349.8	430	504.4	436	835	588	590	285	285	285	300
	2011	312	195	161	174	131	388						
FOOD SAFETY AND	2004							256	296.4	273.4	344	273.2	240.6
	2005	316	306.1	257	256.9	305	274	280	253	236.9	256	202.5	266.3

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TOXICOLOGY BUILDING 0186	2006	294	252.8	279	419	455	558	526	551.6	623.9	473	538.7	573.9
	2007	473	556.2	556	426.9	375	419	368	476.6	833.1	530	506.6	472.8
	2008	468	496.9	333	329	423	380	346	460.5	544.8	395	245.6	234
	2009	319	277	280	263.5	366	271	401	359.1	365.4	338	140.2	211.1
	2010	185	186	170	207.5	264	342	316	336	350	300	300	392
	2011	344	272	252	190	238	275						
REGIONAL CHILLED WATER PLANT NO. 1 0189	2004							####	10683	7857	1283	63	3
	2005	103	4	25	1242	1241	####	####	15968	10017	3894	19	12
	2006	49	12	117	1480	2774	3923	7637	5172	2873	279	12	20
	2007	13	6	111	560	2664	3167	4342	4445	3209	1559	12	27
	2008	31	32	12	1222	2119	3041	4701	2673	1598	11	10	11
	2009	8	3	3	765	1340	3270	2853	2703	1459	17	24	4
	2010	5	1	176	725	2266	4338	3847	3161	800	113	119	244
	2011	21	29	30	496	2807	3402						
ENGINEERIN G RESEARCH COMPLEX 0203A	2004							298	399.8	343.1	360	380.4	205.2
	2005	221	494.9	391	437.6	318	318	318	284.9	236	173	256.7	177
	2006	183	173.6	329	233.3	256	271	361	229.3	432.3	470	601.9	498.4
	2007	539	491.1	450	424.3	524	412	485	531.3	637.5	363	295.7	179.4
	2008	445	396.5	315	338.3	360	202	357	255	313.7	389	215.4	319.7
	2009	361	378.3	404	443.3	354	459	412	408.7	229.7	349	307.7	335.2
	2010	559	387.4	253	478	572	713	678	1024	235	818	757	695
	2011	378	286	388	101	273	273						
	2007									0	0	0	0
	2008	0	13.4	137	661.5	205	165	282	295.6	237	216	150.3	84.5
	2009	150	231.7	164	226.3	128	479	462	476.1	356.8	228	347.4	111.8
	2010	198	148.4	722	304.1	390	340	1769	400	264	148	432	824

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2011	159	668	217	358	358	358						
[3]UNIVERSITY RESEARCH CONTAINMENT FACILITY 0211	2010							300	500	300	300	300	400
	2011	400	400	400	300	300	300						
	2010							3968	4260	4298	460	1817	1321
	2011	1693	1487	3496	2200	2199	2001						
PAVILION FOR AGRICULTURE AND LIVESTOCK EDUCATION - HORSE BAR 0212A	2004							194	157.5	148.7	313	222.7	251.6
	2005	86.6	186	291	105	193	214	251	222	162.6	310	179.7	191.4
	2006	111	165.1	306	212.6	146	198	230	183.8	203.5	269	154.9	190.6
	2007	75.8	301	301	143.2	196	196	266	204.5	155.7	340	159.4	188.9
	2008	65.1	209.3	281	220	173	167	183	246.6	143.6	365	123.7	180
	2009	327	246.2	194	231.1	178	159	226	176.8	164.9	347	100.2	224.7
	2010	129	183.3	323	262.3	200	211	225	308	308	113	112	105
	2011	76	104	116	36	37	50						
RADIOLOGY BUILDING 0214	2004							10	17	20	34	27	20
	2005	28	30	19	28	16	16	16	17	27	23	29	21
	2006	14	0	0	0	0	0	0	0	0	0	0	0
	2007	0	0	0	0	0	0	0	0	0	0	0	16
	2008	26	39	54	96	76	60	75	31	62	30	19	11
	2009	41	34	30	47	25	25	23	45	83	29	25	26
	2010	29	35	49	57	23	23	141	464	204	458	765	407
	2011	345	345	174	173	180	180						
DIAGNOSTIC CENTER FOR POPULATION	2010	0	2862.6	1598	1482	1000	965	2886	1021	1671	1700	1262	1655
	2011	1442	1202	1648	1456	1024	836						
	2010	0	2102	746	709	1003	996	1767	1743	3217	569	566	1145

[3] This data appears to be estimated, however, it is believed the fish tanks in this facility consume 3 KGAL per hour. This would result in a annual consumption of 26,280 KGAL rather than the estimated 4,200 KGAL per year.

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AND ANIMAL HEALTH 0215	2011	591	824	800	780	933	1443						
PARKING RAMP NO.1 SHAW LANE (NEW) 0219	2004							70.2	20.4	16.8	25.4	17.7	15
	2005	18	16.4	15	21.2	9.4	7.7	7.6	11.8	23.2	42.1	17.1	13.7
	2006	18.9	21.5	18.4	27.9	9.4	8.8	50.1	79.5	116.7	76.7	20.1	13
	2007	17.9	16.2	17.4	20.5	8.9	9.3	8.4	19.3	23.9	23.7	24.7	9.5
	2008	21.7	36	17.2	21.6	10	9.1	11.3	13.8	39.9	26	18.8	10.7
	2009	16.2	15.8	13.2	26.2	9.3	11.9	11	21.3	30.2	26.1	20.4	7.5
	2010	16.5	16.8	17.7	17	6.6	16.6	10	12	32	18	6	21
	2011	14	26	16	14	10	8						
MSU SURPLUS STORE & RECYCLING CENTER 0223	2009								204	20	21	9	6
	2010	11	24	6	5	5	4	8	9	6	6	7	3
	2011	7	6	8	5	6	9						
SNYDER AND PHILLIPS HALL 0300	2004							280	1000	1458	1629	1334	808
	2005	1213	1458	996	1513	310	640	640	973	1446	1551	1131	955
	2006	1101	1521	1098	1547								
	2007							400	1000	1000	1000	1000	1010
	2008	588	1808.3	1134	1401	1108	585	668	795.6	1424	1837	1414.7	916.3
	2009	508	1451.4	1015	1297	1389	790	1001	715.3	1123	1841	1171.1	1134
	2010	599	1306.7	964	1478	792	713	1001	1067	1711	580	1288	1129
	2011	1228	1719	1100	902	1104	1216						
MASON AND	2004							590	570	696	753	613	358

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ABBOT HALL 0302	2005	532	603	461	694	371	496	506	488	654	702	543	389
	2006	513	654	483	700	168	337	27	352	866	722	583	372
	2007	561	600	458	679	47	47	47	171	477	417	298	267
	2008	190	464	265	363	218	22	47	74	387	484	391	249
	2009	151	410	275	348	334	35	116	84	291	433	434	319
	2010	172	381	302	511	230	40	139	123	290	419	360	379
	2011	120	295	168	589	352	50						
	2004							324	404	622	731	560	340
	2005	491	547	435	622	264	287	356	426	553	601	454	345
	2006	664	568	435	607	85	86	197	325	772	774	705	392
	2007	569	612	485	755	73	73	74	180	434	388	262	237
	2008	139	421	255	366	199	101	75	161	366	447	343	216
	2009	134	395	252	401	299	68	144	108	387	482	280	270
	2010	128	313	401	382	184	82	185	179	411	504	811	313
	2011	312	445	227	316	357	937						
CAMPBELL HALL 0304	2004							64.7	228.4	318.4	377	293.9	185.2
	2005	178	436.8	858	893.8	790	60	60	230	502.7	682	330.5	47
	2006	464	333.4	234	362.1	53.4	22.4	62.1	330.1	407.4	352	352.1	142.6
	2007	310	305.1	276	293.4	82.7	8.9	9.2	105.7	335	335	237	214.1
	2008	126	386.6	225	305	211	218	218	195.2	296.6	371	292.5	190.7
	2009	199	242.6	213	271.2	258	100	100	100	134.1	391	243.7	240
	2010	124	282.7	209	384.2	250	186	150	100	150	345	349	169
	2011	285	365	368	273	261	29						
LANDON HALL 0305	2004							117	314.3	774.8	958	761.7	460.4
	2005	674	773.7	630	865.4	133	88	169	404	826	884	679	541
	2006	645	790	601	894	157	62	207	443	1029	900	852	398

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2007	766	790	822	788	572	139	166	378	906	900	643	361
	2008	657	1066	632	867	183	183	183	183	823	977	767	516
	2009	280	760	633	687	776	78	59	140	630	1046	718	723
	2010	400	774	570	953	497	225	309	277	905	822	844	783
	2011	798	552	886	863	509	209						
YAKELEY AND GILCHRIST HALL 0306	2004							583	558	850	876	675	441
	2005	614	667	550	770	313	785	585	510	854	911	614	689
	2006	609	669	993	452	302	327	231	647	779	701	630	347
	2007	593	582	585	623	433	268	566	572	655	792	558	567
	2008	341	856	542	690	436	61	43	382	768	915	721	549
	2009	400	786	514	580	650	143	119	309	729	1172	1189	439
	2010	611	873	773	1105	673	611	705	677	762	1103	1272	500
	2011	770	916	827	1167	700	1000						
	2004							256	240.5	405.6	454	321.6	216.5
	2005	287	395.3	236	231.1	130	173	150	200	297.4	379	263.4	220
	2006	260	320	240	350	90	90	110	281	349	270	370	160
	2007	300	340	540	760	750	70	128	167.5	314.2	306	217.9	209.7
	2008	125	326.9	193	258.4	160	12.9	25	79	312.5	404	316	205.4
	2009	138	317.7	227	279.2	293	31.6	37.5	49.3	155.8	396	175.9	241.4
	2010	126	262.1	190	305.8	127	22.9	14	13	32	18	13	14
	2011	23	0	0	0	0	0						
WILLIAMS HALL 0308	2004							140	176	457	461	337.5	275.6
	2005	482	343.7	279	388.5	123	157	344	43.2	394.9	453	416.8	121.1
	2006	341	363.5	284	428	128	81.2	162	256.3	491.3	440	402.5	321.4
	2007	406	364.6	355	602.2	188	93.2	100	138.1	396.1	400	400	320
	2008	400	360	350	400	5.5	3	1.6	60.5	361.8	419	285.1	282.8

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2009	88.8	109.7	75.3	87.9	86.7	12	15.9	15.1	85.5	162	93.6	92.8
	2010	40.4	204.4	217	391.1	90	123	9	8	92	176	215	100
	2011	40	44	43	52	34	33						
MARY MAYO HALL 0309	2004							26	108	353	371	283	176
	2005	257	308	252	366	48	22	24	116	314	379	274	204
	2006	288	332	275	425	54	67	83	168	444	371	365	130
	2007	334	357	304	313	111	15	86	137	324	343	242	192
	2008	118	367	230	318	0	0	0	0	0	0	0	0
	2009	0	0						0	890	1031	300	220
	2010	273	337	298	409	228	142	189	218	380	440	329	212
	2011	313	322	305	406	115	45						
BUTTERFIELD HALL 0310	2004							58	207	533	515	393	251
	2005	429	425	353	506	190	48	96	189	505	659	387	275
	2006	568	534	395	517	43	122	122	212	688	373	684	372
	2007	411	555	384	614	144	69	58	245	706	575	546	167
	2008	570	961	435	625	96	105	65	389	735	532	462	160
	2009	515	625	566	830	165	166	97	277	178	1084	808	143
	2010	1208	661	482	635	160	650	100	270	200	499	200	332
	2011	467	507	469	531	193	113						
RATHER HALL 0311	2004							416	813	1161	1597	1334	1421
	2005	736	586	425	597	138	95	36	224	550	666	1155	305
	2006	505	611	467	570	64	105	210	344	799	745	578	292
	2007	545	571	406	647	92	6	103	450	555	582	588	123
	2008	505	340	358	448	53	58	27	283	664	498	459	143
	2009	495	461	368	555	82	362	5	221	204	1026	496	127
	2010	446	482	483	477	200	260	190	191	191	522	250	292

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2011	402	305	616	502	103	0						
BRYAN HALL 0312	2004							781	957	1099	1433	1123	867
	2005	1073	1213	1219	1220	871	661	730	923	1286	1692	1387	1523
	2006	1435	1384	1429	1574	932	984	1120	1043	1690	1600	1408	1264
	2007	1408	1482	1109	1638	1813	1773	191	490	1060	1295	1477	890
	2008	1498	1041	1029	1266	584	214	59	330	739	562	500	150
	2009	549	552	399	668	329	14	100	30	257	250	250	246.8
	2010	110	112	91.3	57.3	300	200	100	125	397	366	180	256
	2011	321	388	330	390	117	69						
BRODY HALL 0313	2004							863	1262	1616	2250	1845	852
	2005	1096	1306	1123	1285	750	764	799	1058	1616	2020	1249	1221
	2006	1337	1415	1430	1779	1030	1201	1458	1236	2182	2051	1869	1533
	2007	1954	1821	1688	2606	1513	1313	1107	1807	2082	2238	2235	1138
	2008	2234	1769	1722	2052	948	897	1247	1417	2360	1865	1707	1081
	2009	1571	1610	1541	2076	800	800	1200	1400	2300	1900	1700	1000
	2010	1600	1600	1500	2000	800	800	1200	1400	2300	1500	640	550
	2011	771	949	939	1015	247	206						
EMMONS HALL 0314	2004							1325	1325	1490	1709	1499	1308
	2005	2128	1674	1633	1708	1569	1617	1739	1333	1049	1275	1500	1417
	2006	1263	1101	1214	1177	701	1397	1567	2941	1178	1142	1149	824
	2007	1001	990	915	1444	735	985	895	1080	1559	1197	1497	936
	2008	1541	1167	975	1195	530	266	459	745	1403	1010	979	731
	2009	1114	674	481	549	360	121	70	152	723	608	544	179
	2010	513	498	509	20	20	20	20	20	20	20	20	20
	2011	20	20	20	20	20							
BAILEY HALL	2004							2045	2351	2487	2579	2313	2096

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0315	2005	1810	2080	1736	1968	1523	1523	1608	1291	1670	1670	1132	1815
	2006	1565	1647	1249	1383	858	825	589	695	1241	1279	1149	936
	2007	1202	1209	1064	1310	665	890	865	1166	1116	1247	1216	709
	2008	1269	1006	979	1208	675	592	925	962	1577	1255	1262	1077
	2009	1264	1203	503	353	248	27	13	143	836	543	453	108
	2010	447	450	433	350	250	20	13	338	338	481	240	294
	2011	433	516	431	530	91	0						
ARMSTRONG HALL 0316	2004							700	1026	1034	1091	889	586
	2005	814	878	605	1168	558	494	454	587	992	1135	761	762
	2006	938	996	948	1114	562	544	399	854	1471	1646	959	587
	2007	950	980	786	1182	401	280	303	680	924	1046	1223	706
	2008	1273	1008	1011	1238	434	484	651	704	1332	1087	1101	364
	2009	585	571	422	738	686	500	650	700	198.9	200	100	323
	2010	202	197.6	163	700	171	200	257	257	257	584	250	335
	2011	419	493	433	521	118	53						
SHAW HALL 0317	2004							288	873	1632	2079	1523	1046
	2005	1435	1683	1607	1712	540	529	946	1147	2511	2231	1403	1103
	2006	1385	1658	1429	1887	427	533	954	944	2500	2500	1100	1459
	2007	1987	1964	1500	661	968	614	616	3562	2621	2498	2733	1451
	2008	2580	2069	1835	1891	214	458	953	1229	2380	1813	1630	728
	2009	1723	2055	1564	2351	327	797	1080	1218	2673	2375	2607	1261
	2010	1000	2723	1937	1912	405	745	1246	1193	2476	1134	3101	3859
	2011	3828	1645	1218	2777	400	1845						
VANHOOSEN HALL 0319	2007											0	39
	2008	140	158	116	101	20	54	61	108	143	120	128	35
	2009	183	133	122	133	13	25	32	86	194	133	168	61

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2010	126	134	129	88	8	17	22	69	144	454	239	130
	2011	105	264	250	88	28	15						
OWEN GRADUATE HALL 0320	2004							1049	1638	1897	2010	1908	1262
	2005	1571	1833	1652	1962	1443	1255	640	1700	1900	2200	976	2214
	2006	1630	1814	1443	2026	1055	1200	1526	1240	2172	2071	1903	1464
	2007	1986	1826	1603	2069	1103	1386	931	1647	2270	2198	2580	675
	2008	2280	1914	1974	1886	1114	1113	1450	1829	2453	2057	1575	644
	2009	1568	1531	1658	1556	1100	1100	1400	3770	2224	1659	2209	714
	2010	1574	1349	2074	1452	1100	1174	776	2240	1794	2002	1706	1136
	2011	1500	1500	1500	1609	1128	1002						
CASE HALL 0321	2009												0
	2010	5260	1488	1381	1575	706	371	388	530	1794	1871	1493	1223
	2011	1365	1609	1363	1569	407	349						
WILSON HALL 0322	2009												0
	2010	1350	2091	1806	2194	787	442	228	444	2321	2314	1992	1235
	2011	1785	2099	1967	2239	530	487						
WONDERS HALL 0323	2004							570	641	1990	2017	1694	1336
	2005	1336	2150	1476	1844	631	495	713	1667	2230	2089	1542	1179
	2006	1500	1800	1590	2040	240	700	1050	1040	2010	2130	1800	990
	2007	1650	2180	2040	1940	650	490	1150	1111	2079	1830	1836	937
	2008	1247	2275	1230	2226	560	229	491	974	1827	2092	1596	1410
	2009	2634	2496	2000	1000	1000	1411	1132	520	2003	2755	1472	2573
	2010	2400	1620	1547	1773	734	249	1201	1184	1733	1705	1505	981
	2011	2948	2332	1466	1600	532	542						
MCDONEL HALL	2009												0
	2010	3438	1627	2620	1573	1365	1649	848	1509	1572	2144	1672	1300

Table 11 (cont'd)

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0324	2011	1636	2057	1800	1963	567	318						
UNIVERSITY HOUSING OFFICE 0325	2010						0	3	5	3	3	3	3
	2011	3	3	3	3	3	3						
AKERS HALL 0326	2009									0	1000	1000	1197
	2010	1940	1456	2179	1484	594	781	906	2012	1514	1300	700	1081
	2011	1690	1958	1613	1854	670	450						
HOLMES HALL 0330	2004							1685	1942	3168	3419	3062	1935
	2005	2608	3315	2514	3724	673	706	657	1414	2897	3609	2706	1499
	2006	2622	2956	2485	2930	536	450	1379	1361	3347	3064	2434	1650
	2007	2685	3202	2172	3703	462	596	587	1363	3707	3739	4548	2496
	2008	4450	2918	3703	3026	332	903	1012	2910	4265	3455	2834	2470
	2009	3330	3212	3132	3458	552	1117	1071	1587	3708	2982	3111	1331
	2010	3090	2523	3960	2480	866	1902	1827	1994	2707	3762	1491	2540
	2011	3044	2500	2513	2932	1116	641						
HUBBARD HALL 0331	2010	0	734	2282	2000	1000	1000	844	844	2289	2195	2000	1205
	2011	2088	2312	1915	2716	539	214						
HOLDEN HALL 0332	2009												0
	2010	5523	1762	1408	2175	724	707	744	777	2629	1811	1641	1162
	2011	1536	1778	1522	1828	394	46						
VETERINARY RESEARCH CENTER - LARGE ANIMAL BARN 0446A	2004							57	93	103	69	85	100
	2005	149	247	164	128	146	77	127	148	115	154	78	90
	2006	89	84	94	97	74	88	90	112	99	106	94	378
	2007	336	388	206	146	208	120	221	224	530	220	227	376
	2008	356	556	422	316	356	369	352	519	289	321	300	400
	2009	400	400	400	300	300	300	300	500	300	300	300	400

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2010	400	400	400	300	300	300						
	2011												
	2004							1220	1935	1792	2184	2110	2178
	2005	2534	2393	2164	2681	2610	2526	3319	4080	3781	3731	3872	4311
	2006	3788	2672	3320	3573	3015	3595	3598	3744	4095	3405	4182	4737
	2007	3783	5091	4219	3642	3837	3403	4277	5453	4045	4280	3851	3851
	2008	3780	4901	4121	4048	4731	4537	3145	5098	4310	5339	3734	4032
	2009	5338	4135	4046	3974	5210	4036	5458	4615	4444	6212	3297	3999
	2010	6026	4189	4523	5920	4556	4022						
	2011												
M.S.U. FEDERAL CREDIT UNION - MAIN OFFICE 0606	2010	0	0	0	0	2.7	0	48	17	223	52	0	0
	2011	0	0	0	0	2	4						
	2009												0
	2010	22.5	39	15.5	32.9	22	16.1	69	60	240	81	36	36
	2011	17	28	49	14	25	80						
MUSIC/MUSIC PRACTICE 1121	2004							0	0	0	0	0	0
	2005	0	0	144	57.1	32.3	44.7	46.3	60.8	121.9	63.9	37.9	27.6
	2006	42.7	44.1	43.3	58.3	82.2	45.8	61.3	55.2	64.2	66.6	51.5	26.8
	2007	50.5	50.4	55.7	76.2	31.3	41.7	55.7	63.5	73.3	70	120.8	141.1
	2008	134	45	53	89.5	19.5	24.4	61.5	50.1	75	78.6	122.5	18.5
	2009	52.2	57.2	49.3	78.5	12.6	41.3	16.6	39.6	99	166	51.3	13.9
	2010	45.4	52	60.3	67.7	0	0	28	28	28	28	28	28
	2011	36	56	53	37	97	33						
VETERINARY MEDICAL CENTER	2004							4.2	4.5	9.4	8	5.4	2.8
	2005	4.1	4.8	5.9	8.2	0	64.1	15.9	18.9	25.3	20.7	8.7	14.2
	2006	12.1	11	12.1	14.1	12.4	14.2	17.1	14.5	18	7.8	11.55	11.55

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
170	2007	11.6	11.55	12.3	13.8	15.4	12.2	12.2	12.9	19.4	22.9	16.3	6.7
	2008	11.1	11	14.1	14.3	10.7	13.8	20.5	14.6	16.2	17.1	14.7	11
	2009	13.7	12.2	14.7	21.8	12	14.8	8.8	8.9	15	11.4	14	3.6
	2010	7.7	9.5	10.9	6.8	6	6.1	3	4	12	6	4	5
	2011	21	12	5	5	10	7						
	2006						0	0	0	0	0	0	0
	2007	0	0	0	0	0	0	0	0	0	0	0	0
	2008	0	0	0	1199	459	608	1037	455.6	196.1	186	168.8	215.2
	2009	180	186	177	227	192	233	205	225.7	229.5	177	271.1	140.7
	2010	175	167.9	243	174.1	177	219	180	384	256	294	331	270
	2011	402	483	127	137	245	174						
	2008	0	0	0	0	0	0	0	322	568	444	454	574
	2009	526	546	413	592	677	518	445	450	538	382	399	447
	2010	387	332	532	394	421	555	551	629	455	282	310	335
	2011	1367	742	457	438	575	500						
CLINICAL CENTER 2000	2004							0	0	0	0	0	0
	2005	0	0	0	0	0		0	0	0	2.8	2.8	2.9
	2006	3.5	2.9	3.2	3.5	4.4	5.5	6.9	4.4	3.9	3.2	3.3	2.4
	2007	3.5	3	2.9	3.6	3.4	2.8	3	3.1	3.4	3.6	4.4	2.5
	2008	3.8	2.9	3.2	3.9	3.3	3.2	4.2	3	4.8	3.8	2.9	3.4
	2009	3.6	3.5	3.3	4.1	3.2	3.8	3.2	3.1	3.9	2.8		0
	2010	2.8	2.1	4	2.8	2.4	5.4	1	3	1	2	2	8
	2011	3	5	5	1	10	7						
DEMMER SHOOTING RANGE 224	2010	0	2.477	4.35	1.745	11.7	16.9	26	21	4	2	2	2
	2011	2	1	6	2	2	3						
FACULTY	2004							230	322	463	489	428	356.5

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BRICK APARTMENT S 7000	2005	357	356.5	357	331	325	278	288	266	351	346	275	293
	2006	365	396	506	554	474	377	340	313	366	326	305	320
	2007	288	320	279	276	238	224	127	191	226	233	325	199
	2008	238	340	510	584	657	446	494	618	554	723	559	646
	2009	646	646	255	216	255	132	140	107	164	218	112	109
	2010	208	200	304	184	250	270	140	588	844	1105	1220	1346
	2011	1451	1590	1690	321	344	0						
FOOTBALL BUILDING 77	2004							74	152	140	139	131	230
	2005	129	124	86	95	49	77	93	199	159	163	88	64
	2006	92	106	143	164	76	112	68	181	165	134	113	61
	2007	80	122	106	122	75	110	70	180	160	130	110	120
	2008	80	120	100	120	75	110	70	180	160	130	229	64
	2009	60	116	88	100	78	106	106	143	116	158	84	60
	2010	58	76	69	103	34	68	71	80	194	127	64	53
	2011	95	73	68	118	43	81						
	2004							19	23	28	25	17	11
	2005	11	16	14	17	21	24	24	33	34	31	19	15
	2006	15	18	23	31	5	18	18	38	40	38	27	23
	2007	21	29	59	32.4	32.4	32.4	32.4	32.4	59	48	30	18
	2008	13	29	35	29	20	26	37	57	47	52	26	18
	2009	14	25	20	27	19	19	58	30	36	85	21	22
	2010	12	26	18	40	19	24	31	29	82	22	19	20
	2011	46	33	41	35	16	35						
WHARTON CENTER 0085	2004							15	37	51	52	89	68
	2005	40	84	73	68	43	74	18	47	52	76	75	29
	2006	130	266	92	94	76	15	30	36	53	81	112	31

Table 11 (cont'd)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	2007	67	53	57	100	49	44	196	42	30	125	126	22
	2008	83	61	70	94	27	113	79	118	87	51	90	100
	2009	101	94	174	220	24	24	15	21	32	41	37	68
	2010	72	37	59	83	177	12	9	20	19	71	65	77
	2011	58	76	36	29	59	9						
FARRALL AGRICULTURAL ENGINEERING HALL 0091	2004							10.1	12.55	53.48	25.6	24.64	15.34
	2005	18.6	22.6	18.8	28.24	15.8	10.5	9.87	18.58	50.42	22.9	16.36	18.34
	2006	20	26	21	19	19	12	18	38	64	92	21	15
	2007	24	48	2.6	7.3	20.1	13	19	23	27	31	43.6	10.03
	2008	29.7	23.98	31.1	26.46	15.8	25.1	28.3	20.87	34.9	32.2	26.08	15.75
	2009	30.5	28	27.9	31.62	33.1	17	22.6	37.44	42.89	30.4	37.77	21.63
	2010	37	25.74	64.8	5.41	20.3	20.7	49	32	30	32	30	26
	2011	25	39	27	33	23	18						

Appendix B

Inventory of Autoclaves/Sterilizers

*note: Unit price must be greater than $5,000 to be listed in inventory

Table 12: Inventory of autoclaves/sterilizers

Asset Number	Tag Number	Organization Owner Organization Code	Building Code	Asset Description	In-Service Date
500405	9945	10046059	215	CONSOLDATED SSR5APD STERILIZER	2/1/1998
500431	9993	10032114	178	STERILIZER SSR-2A-PB CSS K492473	7/1/1996
500367	11211	10002348	179	RAUCH STEAM STERILIZER	6/1/1998
501606	18396	10032098	168	CONSOLIDATED STERILIZER	4/19/2005
501626	18420	10032098	168	CONSOLIDATED STERILIZER	4/19/2005
501768	17587	10002348	179	MODEL 533LS STERILIZER	2/28/2005
504635	23107	10032500	0720N	STEAM STERILIZER, MICROCOMPUTER-CONTROLLED NOTE: NEW EQUIPMENT ITEM NEVER TAGGED BY KBS. SHOULD HAVE BEEN TAGGED IN 2008-09 PRICE INCLUDES $800 TRADE-IN CREDIT OF EXISTING STERILIZER	6/11/2008
503202	12817	10022646	183	CONSOLIDATGED STERILIZER (AUTOCLAVE) MODEL SR-24A CHAMBER	9/8/2000
503644	12164	10002410	86	STERILIZER FIXED 121C	4/17/2000
503297	12994	10032114	178	CONSOLIDATED SSR-3A-PB STERILIZER	11/13/2000
503298	12995	10002673	178	STERILIZER NOTE: 66	11/13/2000
503862	12612	10032114	178	CONSOLIDATED STILLS 7 STERILIZERS MODEL SSR-3A-PB	5/23/2000
503663	12216	10022582	201	REBUILDING OF ETC STERILIZER, CHAMBER	5/1/2000
504740	23229	10022641	183	CONSOLIDATED SSR-3A-PB STERILIZER	2/11/2009
504965	100611	10057673	0181A	CONSOLIDATED SSR-3A-ADVPB	2/8/2010

Table 12 (cont'd)

Asset Number	Tag Number	Organization Owner Organization Code	Building Code	Asset Description	In-Service Date
				STERILIZER	
505192	23931	10002348	179	CONSLIDATED SSR-3A-PB STERILIZER	2/8/2001
505193	23932	10002348	179	CONSLIDATED SSR-3A-PB STERILIZER	2/8/2001
505237	68240	10032142	163	CONSOLIDATED STILLS & STERILIZERS AUTOCLAVE	4/27/2009
519656		10032142	163	Steris Sterilizer	8/13/2011
505152	23880	10002344	180	CASTLE VACUUM STEAM STERILIZER	2/14/2003
505902	15947	10046906	170	CONSOLIDATED STERILIZER gmd 06/19/03 corrected value from $29,468 to $35,624.00. Tag 15888 is part of this tag (15947). Tag 15888 deleted	5/21/2003
506883	14180	10046906	170	STERILIZER	7/23/2001
507876	13267	10002673	0181A	STERILIZER ETN 1300	4/27/2001
507972	15546	10046906	170	STERRAD 100S STERILIZER 15546 WAS PREVIOUSLY ASSIGNED TO SOFTWARE, DELETED AND ASSIGNED TO CURRENT EQUIPMENT. RCK 07-08-04	5/9/2004
507797	15525	10002210	86	AUTOCLAVE STERILIZER CONSOLIDATED FORMERLY#14133; PER CERT 02210, 01-02	7/23/2001
509297	8568	10059512	202	CHAMBER STERILIZER MPS CASTLE	3/1/1994
509939	6170	10032674	178	STERILIZER GRAVITY 3021 AMSCO	2/1/1993
509950	6189	10032674	178	STERILIZER 5460DD AMER 300411 NOTE: GRNHS	7/1/1966
509954	6206	10032674	178	STERILIZER GRAVITY 3021 AMSCO	2/1/1993
508058	16678	10002038	91	STERILMATIC STERILIZERS CHAMBER	4/7/2004
510020	9185	10002344	180	TUTTNAUER-BRINKMAN 3820-E STERILIZER	10/1/1997

Table 12 (cont'd)

Asset Number	Tag Number	Organization Owner Organization Code	Building Code	Asset Description	In-Service Date
508874	16891	10046059	215	GETINGE 233LS STEAM STERILIZER	3/8/2004
509500	5965	10032674	178	STERILIZER 3023 AMSCO	11/1/1992
509391	1576	10016140	81	STERILIZER 2021 AMSCO R811739101	9/1/1991
510745	9697	10046908	170	STERILIZER SSR-3A-PB CSS	8/1/1996
513783	19344	10022646	183	CONSOLIDATED SR-24A DIRECT STEAM HEATED STERILIZER	9/26/2005
512396	847	10057351	211	STERILIZER SG-120 AMSCO 0101995-03	3/1/1995
512193	811	10002348	179	FMC 610-10 STERILIZER	6/1/1991
513768	19328	10059512	202	BETA-STAR STERILIZER	6/16/2006
514435	20536	10028546	330	STERILMATIC STEAM PRESSURE STERILIZER	5/18/2007
514436	20537	10028546	330	STERILMATIC STEAM PRESSURE STERILIZER	5/18/2007
515268	20763	10002161	22	MARKET FORGE STERILIZER NOTE: MSU BIOREFINERY value includes $472.50 freight	6/21/2007
514273	21410	10032674	178	CONSOLIDATED SSR-3A-PB STERILIZER	10/10/2007
514274	21411	10032674	178	CONSOLIDATED SSR-3A-PB STERILIZER	10/10/2007
514381	19482	10002210	86	CONSOLIDATED STERILIZER 1/25/07 GMD PER 05-06 CERT TRANSFERED TO 02210	5/19/2006
514382	19483	10002210	86	CONSOLIDATED STERILIZER 1/25/07 GMD PER 05-06 CERT TRANSFERED TO 02210	5/19/2006
515123	21651	10002161	22	HIRAYAM AUTOCLAVE STERILIZER NOTE: MSU BIOREFINERY	4/22/2008
514908	21588	10032674	178	CONSOLIDATED SSR-3A-PB 20"" X 38"" STERILIZER	11/27/2007

Table 12 (cont'd)

Asset Number	Tag Number	Organization Owner Organization Code	Building Code	Asset Description	In-Service Date
515557	21827	10046518	170	CONSOLIDATED SR-24A-PB STERILIZER	4/29/2008
515965	21925	10059351	186	CONSOLIDATED SR-24C-PB STERILIZER	5/5/2008
519346	101738	10032674	178	Lab 500 Scientific Steam Sterilizer	1/6/2011
519851		10032500	0720N	Steris 110 Scientific Lab Steam Sterilizer	6/7/2011
520274	102775	10016148	0203A	Consolidated SR-24A-ADVPLUS Laboratory Steam Sterilizer	9/8/2011
501819	17642	10002038	91	GETINGE 533LS AUTOCLAVE	2/28/2005
501903	17735	10032098	168	AUTOCLAVE SR-24D	9/22/2004
501916	17748	10032098	168	AUTOCLAVE SSR-3A-PB	9/22/2004
502117	18009	10016148	0203A	MARKET FORGE STERILMATIC AUTOCLAVE, REMANUFACTURED	1/13/2005
502297	18281	10046059	215	MILLIPORE SUPER Q WATER SYSTEM	7/7/2005
502607	101062	10032586	160	BARNSTEAD NANOPURE LIFE SCIENCE WATER SYSTEM	5/5/2010
503202	12817	10022646	183	CONSOLIDATGED STERILIZER (AUTOCLAVE) MODEL SR-24A CHAMBER	9/8/2000
504379	22684	10016250	81	MILLIPORE WATER SYSTEM	6/9/2009
505237	68240	10032142	163	CONSOLIDATED STILLS & STERILIZERS AUTOCLAVE	4/27/2009
505422	100202	10046518	170	MILLIPORE MILLI-Q WATER SYSTEM	12/7/2009
506446	14016	10046638	186	4 BOWL SUPER-Q WATER SYSTEM NOTE: COMMON AREA	6/7/2011

Table 12 (cont'd)

Asset Number	Tag Number	Organization Owner Organization Code	Building Code	Asset Description	In-Service Date
506640	14057	10059512	160	CAGE MOUSE GENTLE AIR SYSTEM WITH AUTO WATERING 2-25-10 change 09 to 06	10/12/2001
506641	14059	10059512	160	CAGE MOUSE GENTLE AIR SYSTEM WITH AUTO WATERING 2-25-10 change 09 to 06	10/12/2001
506642	14060	10059512	160	CAGE MOUSE GENTLE AIR SYSTEM WITH AUTO WATERING 2-25-10 change 09 to 06	10/12/2001
506643	14061	10059512	160	CAGE MOUSE GENTLE AIR SYSTEM WITH AUTO WATERING	10/12/2001
507599	16517	10016250	81	MILLIPORE DIRECT-Q 5 WATER PURIFICATION SYSTEM	3/30/2007
507797	15525	10002210	86	AUTOCLAVE STERILIZER CONSOLIDATED FORMERLY#14133; PER CERT 02210, 01-02	7/23/2001
507901	13317	10032142	163	ULTRAPURE WATER SYSTEM	5/9/2001
508352	14638	10032098	168	STERIS AUTOCLAVE EQUIPMENT, DOOR	4/19/2002
509220	5764	10032580	29	EQUATHERM 392597 WATER BATH	7/1/1983
510207	6435	10032920	24	AMSCO 2020 AUTOCLAVE	11/1/1990
510795	2402	10016167	81	MINI-BONDER UMC AUTOCLAVE	4/1/1986
510920	7089	10002673	0181A	AUTOCLAVE SG-120 AMSCO 10J7WC ETN 1300	9/1/1997
511209	334	10016140	81	AEI BC0200 AUTOCLAVE	11/1/1991
511612	7403	10002410	86	CSS SSR-3APB AUTOCLAVE	8/1/1997
512462	3276	10032098	168	AMSCO 2041 AUTOCLAVE	8/1/1984
512681	3370	10032098	168	CASTLE 60 AUTOCLAVE	11/1/1990
513409	20255	10046638	180	TUTTNAUER 3850E W/STD AUTOCLAVE	3/30/2007

Table 12 (cont'd)

Asset Number	Tag Number	Organization Owner Organization Code	Building Code	Asset Description	In-Service Date
513428	21141	10034586	168	TUTTNAUER 3545EP AUTOCLAVE	10/2/2007
513620	20314	10032114	178	CONSOLIDATED MDF-U5OVC AUTOCLAVE	4/5/2000
514198	19453	10022668	160	TUTTNAUER/BRINKMANN 3545EP AUTOCLAVE	3/9/2006
514502	21495	10002038	91	MILLIPORE ELIX 5 WATER PURIFICATION SYSTEM	2/28/2008
515123	21651	10002161	22	HIRAYAM AUTOCLAVE STERILIZER NOTE: MSU BIOREFINERY	4/22/2008
519399	103861	10049216	164	Haskris R175 Refrigerated Water Recirculating System	1/24/2011
520356	102669	10034646	183	MILLIPORE MILLI Q WATER PURIFICATION SYSTEM	9/29/2011

APPENDIX C

Biomedical Physical Sciences Building sterilizers

*note: Known presence of tempering cold water line

Table 13: Biomedical Physical Sciences Building sterilizers

Equipment Type	Serial #	Exclude Parts and Repair Labor (Bronze)	Exclude All Parts (Bronze +)	Exclude Repair Parts and Labor (Silver)	Exclude Repair Parts (Gold)	Comprehensive (Platinum)	Room #
20X20X38 CENTURY ISO STER	010610102	$1,466	$2,277	$2,175	$2,831	$3,447	6133
20X20X38 CENTURY ISO STER	010530110	$1,466	$2,277	$2,175	$2,831	$3,447	2160B
500 LAB GLASSWARE WASHER	3604501006	$3,050	$3,725	$4,032	$4,600	$4,988	2160B
24x36x48" PREVAC STERILIZER	013620002	$1,642	$2,898	$2,625	$3,514	$4,287	6133
24x36x48" PREVAC STERILIZER	010440113	$1,642	$2,898	$2,625	$3,514	$4,287	2135
500 LAB GLASSWARE WASHER	3605301007	$3,050	$3,725	$4,032	$4,600	$4,988	2160B
20X20X38 CENTURY ISO STER	010610107	$1,466	$2,277	$2,175	$2,831	$3,447	6133
24x36x48" PREVAC STERILIZER	010030105	$1,642	$2,898	$2,625	$3,514	$4,287	6133
20X20X38 CENTURY ISO STER	010540121	$1,466	$2,277	$2,175	$2,831	$3,447	2135
24x36x48" PREVAC STERILIZER	010100107	$1,642	$2,898	$2,625	$3,514	$4,287	2160B
20X20X38 CENTURY ISO STER	010530111	$1,466	$2,277	$2,175	$2,831	$3,447	2160B
20X20X38 CENTURY ISO STER	010530122	$1,466	$2,277	$2,175	$2,831	$3,447	2160B
400 LAB GLASSWARE WASHER	3605401008	$3,050	$3,725	$4,032	$4,600	$4,988	6133
500 LAB GLASSWARE WASHER	3605201004	$3,050	$3,725	$4,032	$4,600	$4,988	2135
400 LAB GLASSWARE WASHER	3604601003	$3,050	$3,725	$4,032	$4,600	$4,988	6133
500 LAB GLASSWARE WASHER	3604301010	$3,050	$3,725	$4,032	$4,600	$4,988	3133
400 LAB GLASSWARE WASHER	3604601004	$3,050	$3,725	$4,032	$4,600	$4,988	4133
400 LAB GLASSWARE WASHER	3605101010	$3,050	$3,725	$4,032	$4,600	$4,988	5133
20X20X38 CENTURY ISO STER	010610106	$1,478	$2,673	$2,334	$3,131	$3,866	4133
20X20X38 CENTURY ISO STER	010540101	$1,478	$2,673	$2,334	$3,131	$3,866	4133

Table 13 (cont'd)

Equipment Type	Serial #	Exclude Parts and Repair Labor (Bronze)	Exclude All Parts (Bronze +)	Exclude Repair Parts and Labor (Silver)	Exclude Repair Parts (Gold)	Comprehensive (Platinum)	Room #
20X20X38 CENTURY ISO STER	010620103	$1,466	$2,277	$2,175	$2,831	$3,447	5133
24x36x48" PREVAC STERILIZER	010450108	$1,642	$2,898	$2,625	$3,514	$4,287	5133
24x36x48" PREVAC STERILIZER	010160102	$1,642	$2,898	$2,625	$3,514	$4,287	3133
20X20X38 CENTURY ISO STER	010600110	$1,478	$2,673	$2,334	$3,131	$3,866	4133
24x36x48" PREVAC STERILIZER	010440108	$1,642	$2,898	$2,625	$3,514	$4,287	5133
400 LAB GLASSWARE WASHER	3604601001	$3,050	$3,725	$4,032	$4,600	$4,988	5133
24x36x48" PREVAC STERILIZER	010520105	$1,642	$2,898	$2,625	$3,514	$4,287	4133
400 LAB GLASSWARE WASHER	3604601002	$3,050	$3,725	$4,032	$4,600	$4,988	4133
20X20X38 CENTURY ISO STER	010550101	$1,466	$2,277	$2,175	$2,831	$3,447	3133
Total		$59,801	$86,662	$85,721	$106,152	$123,349	

	PM Inspections	PM Parts	Repair Labor	Repair Parts
Bronze	Y			
Bronze Plus	Y		Y	
Silver	Y	Y		
Gold	Y	Y	Y	
Platinum	Y	Y	Y	Y

Appendix D

Residence Hall Occupants

Table 14: Residence hall occupants.

	TOTAL HOUSED IN RESIDENCE HALLS	
	Fall Semester 2009	Fall Semester 2010
Akers	1250	1054
Armstrong	446	441
Bailey	419	429
Bryan	398	434
Butterfield	340	340
Campbell	236	255
Case	838	837
Emmons	420	0
Holden	1079	1034
Holmes	1179	1160
Hubbard	1057	1084
Landon	275	272
Mason/Abbot	618	509
Mayo	209	201
McDonel	882	887
Owen	561	699
Rather	424	394
Shaw	855	860
Snyder/Phillips	587	624
VanHoosen	73	81
Williams	194	191
Wilson	983	970
Wonders	908	925
Yakeley	454	463
University Village	304	304

*Data provided by Diane Barker (Barker, 2011)

Appendix E

Building Construction / Addition Dates

Table 15: Building construction / addition dates

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
0002	BERKEY HALL	BERKEY HALL	152169	1947
			Cell Sum: 152169	
0003	OLIN MEMORIAL HEALTH CENTER	OLIN MEMORIAL HEALTH CENTER	38438	1939
	OLIN MEMORIAL HEALTH CENTER	ADDITION 1	61991	1956
	OLIN MEMORIAL HEALTH CENTER	ADDITION 2	5350	1969
			Cell Sum: 105780	
0005	HUMAN ECOLOGY	HUMAN ECOLOGY	67373	1924
	HUMAN ECOLOGY	ADDITION 1	8410	1937
	HUMAN ECOLOGY	ADDITION 2	1889	1980
	HUMAN ECOLOGY	ADDITION 3 - ELECT SUBSTATION	786	1990
			Cell Sum: 78458	
0006	UNION BUILDING	UNION BUILDING	81724	1924
	UNION BUILDING	ADDITION 1	30047	1936
	UNION BUILDING	ADDITION 2	86897	1949
	UNION BUILDING	ADDITION 3	2105	1980
	UNION BUILDING	ADDITION 4	8151	1997
			Cell Sum: 208924	
0008	WILLS, H. MERRILL, HOUSE	WILLS HOUSE	7879	1927

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
			Cell Sum: 7879	
0009	COWLES HOUSE	COWLES HOUSE (ORIGINAL PORTION	5401	1857
	COWLES HOUSE	ADDITION 1	10510	1950
	COWLES HOUSE	ADDITION 2 - PORCH ENCLOSURE	965	2000
			Cell Sum: 16876	
0011	MUSIC BUILDING	MUSIC	34125	1940
	MUSIC BUILDING	ADDITION 1	28560	1956
	MUSIC PRACTICE (0021)	MUSIC PRACTICE	36091	1968
			98776	
0013	MUSEUM	MUSEUM	52067	1924
	MUSEUM	ADDITION 1	2931	1957
			Cell Sum: 54998	
0014	LINTON, ROBERT S., HALL	LINTON HALL	18451	1881
	LINTON, ROBERT S., HALL	ADDITION 1	19878	1947
	LINTON, ROBERT S., HALL	ADDITION 2 - ELECT SUBSTATION	622	1989
	LINTON, ROBERT S., HALL	ADDITION 3 - HANDICAP ACCESS	888	1996
			Cell Sum: 39839	
0015	EUSTACE-COLE HALL	EUSTACE-COLE HALL	9864	1888
	EUSTACE-COLE HALL	ADDITION 1	1568	1998
			Cell Sum: 11432	

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
0016	MARSHALL-ADAMS HALL	MARSHALL-ADAMS HALL	20189	1902
			Cell Sum: 20189	
0017	OLD BOTANY	OLD BOTANY	6711	1892
	OLD BOTANY	ADDITION 1	7473	1908
			Cell Sum: 14184	
0019	CHITTENDEN, ALFRED K., HALL	CHITTENDEN HALL	13489	1901
			Cell Sum: 13489	
0020	COOK, ALBERT J., HALL	COOK HALL	10246	1889
			Cell Sum: 36091	
0022	AGRICULTURE HALL	AGRICULTURE HALL	97896	1909
	AGRICULTURE HALL	ADDITION 1	325	1991
	AGRICULTURE HALL	ADDITION 2 - ANNEX	35759	1999
			Cell Sum: 133979	
0024	NATURAL SCIENCE	NATURAL SCIENCE	191185	1948
	NATURAL SCIENCE	ADDITION 1 ELECT SUBSTATION	1336	2007
			Cell Sum: 192522	
0025	OLD HORTICULTURE	OLD HORTICULTURE	42425	1924
	OLD HORTICULTURE	ADDITION 1	1444	1963
	OLD HORTICULTURE	ADDITION 2	605	1991
			Cell Sum:	

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
			44474	
0027	PSYCHOLOGY BUILDING	PSYCHOLOGY BUILDING	99663	1949
	PSYCHOLOGY BUILDING	ADDITION 1	503	1955
	PSYCHOLOGY BUILDING	ADDITION 2	1384	1973
	PSYCHOLOGY BUILDING	ADDITION 3	13483	1976
			Cell Sum: 115033	
0028	GILTNER HALL	GILTNER HALL (VET CLINIC)	13440	1913
	GILTNER HALL	ADDITION 1 (ANATOMY & RES)	26165	1931
	GILTNER HALL	ADDITION 2 (NORTH WING OF VET)	26567	1938
	GILTNER HALL	ADDITION 3 (SOUTH WING OF VET)	13938	1940
	GILTNER HALL	ADDITION 4 (ANATOMY)	863	1947
	GILTNER HALL	ADDITION 5 (VET & ANATOMY)	171528	1952
	GILTNER HALL	ADDITION 6 (TRANSFORMER ROOM)	1068	1968
	GILTNER HALL	ADDITION 7 (ELEC SUBSTATION)	1355	1994
			Cell Sum: 254924	
0029	KEDZIE HALL (NORTH AND SOUTH)	KEDZIE HALL- NORTH	87945	1927
	KEDZIE HALL (NORTH AND SOUTH)	ADDITION 1 (SOUTH)	69168	1966

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
	KEDZIE HALL (NORTH AND SOUTH)	ADDITION 2 ENCLOSE CHILLER	2064	2004
			Cell Sum: 159178	
0030	ALUMNI MEMORIAL CHAPEL	ALUMNI MEMORIAL CHAPEL	8678	1952
			Cell Sum: 8678	
0031	AUDITORIUM	AUDITORIUM	157282	1940
			Cell Sum: 157282	
0035	COMPUTER CENTER	COMPUTER CENTER	80379	1948
			Cell Sum: 80379	
0047	OLDS HALL	OLDS HALL	73319	1916
	OLDS HALL	ADDITION 1		1932
			Cell Sum: 73319	
0049	LIBRARY	LIBRARY	286516	1955
	LIBRARY	ADDITION 1	2618	1964
	LIBRARY	ADDITION 2	147275	1967
	LIBRARY	ADDITION 3	20622	1995
			Cell Sum: 457030	
0051	INTRAMURAL RECREATIVE SPORTS - CIRCLE	IM REC SPORTS-CIRCLE	72951	1916
	INTRAMURAL RECREATIVE SPORTS - CIRCLE	ADDITION 1	90518	1958
			Cell Sum:	

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
			163469	
0055	KELLOGG CENTER	KELLOGG CENTER	135103	1951
	KELLOGG CENTER	ADDITION 1	4815	1955
	KELLOGG CENTER	ADDITION 2	14535	1955
	KELLOGG CENTER	ADDITION 3	22247	1959
	KELLOGG CENTER	ADDITION 4	55400	1988
			Cell Sum: 232100	
0056	JENISON FIELDHOUSE	JENISON FIELDHOUSE	195373	1940
	JENISON FIELDHOUSE	ADDITION 1	967	1975
	JENISON FIELDHOUSE	ADDITION 2 LOCKER ROOM	6770	2002
			Cell Sum: 203109	
0057	DEMONSTRATION HALL	DEMONSTRATION HALL	96208	1928
	DEMONSTRATION HALL	ADDITION NO. 1		1937
			Cell Sum: 96208	
0058	SPARTAN STADIUM	STADIUM (14,000 SEATS)	0	1923
	SPARTAN STADIUM	ADDITION 1 (27,250 SEATS)	82549	1948
	SPARTAN STADIUM	ADDITION 2 (9,000 SEATS)	9004	1956
	SPARTAN STADIUM	ADDITION 3 (16,000 SEATS)	95757	1957
	SPARTAN STADIUM	ADDITION 4	233246	2006
			Cell Sum: 420556	
0059	MUNN, CLARENCE L., ICE	MUNN ICE ARENA	107511	1974

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
	ARENA			
	MUNN, CLARENCE L., ICE ARENA	ADDITION 1 VIP SUITES	14012	1999
			Cell Sum: 121522	
0060	CENTRAL SERVICES BUILDING	CENTRAL SERVICES	49022	1948
	CENTRAL SERVICES BUILDING	ADDITION 1	9598	1952
	CENTRAL SERVICES BUILDING	ADDITION 2 - DOCK AREA	0	1953
	CENTRAL SERVICES BUILDING	ADDITION 3	11415	1956
			Cell Sum: 70035	
0067	HANNAH, JOHN A., ADMINISTRATION BUILDING	HANNAH ADMINISTRATION BUILDING	170215	1968
			Cell Sum: 170215	
0068	LAUNDRY BUILDING	LAUNDRY BUILDING, M.S.U.	72411	1968
			Cell Sum: 72411	
0069	BRESLIN, JACK, STUDENT EVENTS CENTER	BRESLIN, JACK, STUDENT EVENTS	246693	1989
	BRESLIN, JACK, STUDENT EVENTS CENTER	ADDITION 1 BERKOWITZ	31427	2001

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
			Cell Sum: 278120	
0077	DUFFY "HUGH" DAUGHERTY FOOTBALL AND CLARA BELL SMITH STUDENT ATHLETE ACADEMIC CENTER	DAUGHERTY FOOTBALL BUILDING	21656	1980
	DUFFY "HUGH" DAUGHERTY FOOTBALL AND CLARA BELL SMITH STUDENT ATHLETE ACADEMIC CENTER	ADDITION 1 FOOTBALL PRACTICE	98511	1985
	DUFFY "HUGH" DAUGHERTY FOOTBALL AND CLARA BELL SMITH STUDENT ATHLETE ACADEMIC CENTER	ADDITION 2	19873	1997
	DUFFY "HUGH" DAUGHERTY FOOTBALL AND CLARA BELL SMITH STUDENT ATHLETE ACADEMIC CENTER	ADDITION 3 STUDENT A.A.C	39814	1998
	DUFFY "HUGH" DAUGHERTY FOOTBALL AND CLARA BELL SMITH STUDENT ATHLETE ACADEMIC CENTER	ADDITION 4 SKANDALARIS	23028	2008
	DUFFY "HUGH" DAUGHERTY FOOTBALL AND CLARA BELL SMITH STUDENT ATHLETE ACADEMIC CENTER	ADDITION 5	190	2010
			Cell Sum: 203071	

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
0078	WELLS HALL	WELLS HALL	207791	1967
	WELLS HALL	ADDITION 1	22317	1970
			Cell Sum: 230108	
0079	BESSEY HALL	BESSEY HALL	137398	1961
	BESSEY HALL	ADDITION 1	13265	1994
			Cell Sum: 150663	
0080	BUSINESS COLLEGE COMPLEX (EPPLEY)	BUS.COLLEGE COMPLEX (EPPLEY)	87819	1961
	BUSINESS COLLEGE COMPLEX (EPPLEY)	ADDITION 1 ELI BROAD	126564	1993
			Cell Sum: 214383	
0081	ENGINEERING BUILDING	ENGINEERING BUILDING	177894	1961
	ENGINEERING BUILDING	ADDITION 1	22442	1962
	ENGINEERING BUILDING	ADDITION 2	139173	1989
	ENGINEERING BUILDING	ADDITION 3	85252	1996
	ENGINEERING BUILDING	ADDITION 4 - VESTIBULE	643	2008
			Cell Sum: 425404	
0082	URBAN PLANNING & LANDSCAPE ARCHITECTURE - INSTRUCTIONAL MEDIA CENTER	URBAN PLANNING LANDSCAPE ARCH	30972	1966
	URBAN PLANNING & LANDSCAPE ARCHITECTURE - INSTRUCTIONAL MEDIA	ADDITION 1 INSTRUCTIONAL MEDIA	16041	1966

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
	CENTER			
			Cell Sum: 47013	
0083	MSU COLLEGE OF LAW	MSU - DCL	185633	1997
			Cell Sum: 185633	
0084	COMMUNICATION ARTS & SCIENCES BUILDING	COMMUNICATION ARTS	262442	1981
			Cell Sum: 262442	
0085	WHARTON, CLIFTON & DELORES, CENTER FOR PERFORMING ARTS	WHARTON CENTER	158453	1982
	WHARTON, CLIFTON & DELORES, CENTER FOR PERFORMING ARTS	ADDITION 1 ADMIN OFFICE	22542	2009
	WHARTON, CLIFTON & DELORES, CENTER FOR PERFORMING ARTS	ADDITION 2 COVER LOADING DOCK	6509	2009
			Cell Sum: 187505	
0086	PLANT & SOIL SCIENCES BUILDING	PLANT AND SOIL SCIENCES	275556	1986
			Cell Sum: 275556	
0087	PUBLIC SAFETY	PUBLIC SAFETY	26636	1975

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
	PUBLIC SAFETY	ADDITION 1	1029	1981
	PUBLIC SAFETY	ADDITION 2	10305	1992
			Cell Sum: 37970	
0089	OYER, HERBERT J., SPEECH AND HEARING CENTER	OYER SPEECH & HEARING CENTER	19895	1968
			Cell Sum: 19895	
0091	FARRALL, A.W., AGRICULTURAL ENGINEERING HALL	AGRICULTURE ENGINEERING HALL	72985	1948
	FARRALL, A.W., AGRICULTURAL ENGINEERING HALL	ADDITION 1	3634	1999
			Cell Sum: 76620	
0093	PLANT SCIENCE GREENHOUSE	ORIGINAL BUILDING	10717	1942
	PLANT SCIENCE GREENHOUSE	ADDITION 1 - PLANT SCI GRNHSE	60945	1949
	PLANT SCIENCE GREENHOUSE	ADDITION 2 - GRNHSE W RANGE	2023	1956
	PLANT SCIENCE GREENHOUSE	ADDITION 3 - GRNHSE W RANGE	5819	1958
	PLANT SCIENCE GREENHOUSE	ADDITION 4 - GRNHSE W RANGE	1596	1962
	PLANT SCIENCE GREENHOUSE	ADDITION 6 - GRNHSE W RANGE	4266	1981

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
0098C	PLANT SCIENCE GREENHOUSE (EAST RANGE)	GREENHOUSE	18717	1966
	PLANT SCIENCE GREENHOUSE (EAST RANGE)	GREENHOUSE (EAST RANGE)	2016	1980
	PLANT SCIENCE GREENHOUSE (EAST RANGE)	TRANSGENIC GREENHOUSE	3054	1998
			109153	
0096	WATER RESERVOIR	WATER RESERVOIR	4225	1951
	WATER RESERVOIR	ADDITION 1	896	1973
	WATER RESERVOIR	ADDITION 2	2900	1987
	WATER RESERVOIR	ADDITION 3	1193	1988
			Cell Sum: 9214	
0131	FIRE STATION	FIRE STATION	8334	1955
	FIRE STATION	ADDITION 1	1098	1981
			Cell Sum: 9433	
0132	ANTHONY HALL	ANTHONY HALL	226275	1955
	ANTHONY HALL	ADDITION 1	895	1964
	ANTHONY HALL	ADDITION 2	92006	1997
			Cell Sum: 319176	
0133	ANGELL, ROBERT D., UNIVERSITY SERVICES BUILDING	ANGELL, R.D., UNIV SERVICES	75441	1988
	ANGELL, ROBERT D., UNIVERSITY SERVICES BUILDING	ADDITION 1 GAS STORAGE	753	1998
	ANGELL, ROBERT D., UNIVERSITY SERVICES	ADDITION 2 STORAGE	6352	2001

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
	BUILDING			
			Cell Sum: 82546	
0142	STUDENT SERVICES	STUDENT SERVICES	121938	1957
			Cell Sum: 121938	
0144	ERICKSON HALL	ERICKSON HALL	209361	1957
	ERICKSON HALL	ADDITION 1	1318	1964
	ERICKSON HALL	ADDITION 2	2515	1974
	ERICKSON HALL	ADDITION 3	7015	2006
	ERICKSON HALL	ADDITION 4	355	2009
			Cell Sum: 220563	
0150	KRESGE ART CENTER	KRESGE ART CENTER ORIG BLDG	84466	1958
	KRESGE ART CENTER	ADDITION 1	14116	1966
	KRESGE ART CENTER	ADDITION 2 KILN & FOUNDRY ROOM	816	1973
	KRESGE ART CENTER - SCULPTURE STUDIO (0150A)	KRESGE ART SCULPTURE STUDIO	7695	1966
			107092	
0151	INTRAMURAL RECREATIVE SPORTS WEST	INTRAMURAL RECREATIVE-WEST	230288	1958
	INTRAMURAL RECREATIVE SPORTS WEST	ADDITION 1 COURTYARD	5284	2005
			Cell Sum: 235573	

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
0154	MANLY MILES BUILDING	MANLY MILES BUILDING	58519	1959
			Cell Sum: 58519	
0158	LANDSCAPE SERVICES	LANDSCAPE SERVICES	19502	1959
	LANDSCAPE SERVICES	ADDITION 1	12811	1965
			Cell Sum: 32313	
0160	BIOMEDICAL PHYSICAL SCIENCES BUILDING	BIOMEDICAL PHYSICAL SCIENCES	377208	2001
			Cell Sum: 377208	
0163	CHEMISTRY	CHEMISTRY	286974	1963
	CHEMISTRY	ADDITION 1 SUBSTATION	2893	1997
	CHEMISTRY	ADDITION 2	32034	2008
			Cell Sum: 321901	
0164	CYCLOTRON	CYCLOTRON	32600	1963
	CYCLOTRON	ADDITION 1	17224	1968
	CYCLOTRON	ADDITION 2 WEST HIGH BAY	3132	1978
	CYCLOTRON	ADDITION 3	5505	1979
	CYCLOTRON	ADDITION 4	39465	1982
	CYCLOTRON	ADDITION 5	6436	1985
	CYCLOTRON	ADDITION 6	6445	1988
	CYCLOTRON	ADDITION 7 EAST HIGH BAY	6441	1996
	CYCLOTRON	ADDITION 8 CRYOGENIC EXPANSION	7267	1999

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
	CYCLOTRON	ADDITION 9 (OFFICE ADD)	13389	2003
	CYCLOTRON	ADDITION 10 ASSEMBLY	14912	2004
	CYCLOTRON	ADDITION 11 OFFICE ADDITION	26802	2009
	CYCLOTRON	ADDITION 12 LOW ENERGY RES	12480	2009
			Cell Sum: 192098	
0165	ABRAMS PLANETARIUM	ABRAMS PLANETARIUM	17465	1963
			Cell Sum: 17465	
0167	PHYSICAL PLANT SHOPS & OFFICE BUILDING	PHYSICAL PLANT	95436	1963
	PHYSICAL PLANT SHOPS & OFFICE BUILDING	ADDITION 1	1764	1969
	PHYSICAL PLANT SHOPS & OFFICE BUILDING	ADDITION 2- ENCLOSE DOCK		1994
			Cell Sum: 97200	
0168	BIOCHEMISTRY	BIOCHEMISTRY	157744	1964
			Cell Sum: 157744	
0169	INTERNATIONAL CENTER	INTERNATIONAL CENTER	94451	1964
	INTERNATIONAL CENTER	ADDITION 1	17087	1980
	INTERNATIONAL CENTER	ADDITION 2 DELIA KOO	22014	2003
			Cell Sum: 133552	

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
0170	VETERINARY MEDICAL CENTER	VETERINARY MEDICAL CENTER	180862	1965
	VETERINARY MEDICAL CENTER	ADDITION 1	159547	1991
	VETERINARY MEDICAL CENTER	ADDITION 2 ONCOLOGY	39162	2005
	VETERINARY MEDICAL CENTER	ADDITION 3 SECOND FLOOR F BLDG	3654	2007
	VETERINARY MEDICAL CENTER	ADDITION 4 SMALL ANIMAL ENTRAN	217	2007
0170A	VETERINARY MEDICAL CENTER - MARY ANNE MCPHAIL EQUINE PERFORMANCE CENTER	HAY STORAGE	10524	1989
	VETERINARY MEDICAL CENTER - MARY ANNE MCPHAIL EQUINE PERFORMANCE CENTER	ADDITION 1 EQUINE PERFORM CNTR	23782	2001
0170B	VETERINARY MEDICAL CENTER - MATILDA R. WILSON, PEGASUS CRITICAL CARE CENTER	PEGASUS CRITICAL CENTER	8818	2005
			426565	
0171	FOOD STORES	FOOD STORES	81230	1964
	FOOD STORES	ADDITION 1 RELOCATE BAKERY	12227	2006
			Cell Sum: 93457	

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
0175	INTRAMURAL RECREATIVE SPORTS EAST	INTRAMURAL REC SPORTS EAST	75237	1988
			Cell Sum: 75237	
0176	GEOGRAPHY BUILDING	GEOGRAPHY BUILDING	31221	1965
			Cell Sum: 31221	
0177	PACKAGING	PACKAGING LABORATORY	20781	1964
	PACKAGING	ADDITION 1	29681	1987
			Cell Sum: 50462	
0178	PLANT BIOLOGY LABORATORIES	PLANT BIOLOGY LABORATORIES	62709	1966
	PLANT BIOLOGY LABORATORIES	ADDITION 1	55202	1968
	PLANT BIOLOGY LABORATORIES	ADDITION 2 BOTANY	31429	1968
	PLANT BIOLOGY LABORATORIES	ADDITION 3	40211	1985
			Cell Sum: 189550	
0179	TROUT, G. MALCOLM, FOOD SCIENCE AND HUMAN NUTRITION BUILDING	TROUT, M.G., FOOD SCIENCE BLDG	115530	1966
	TROUT, G. MALCOLM, FOOD SCIENCE AND HUMAN NUTRITION BUILDING	ADDITION 1 PENTHOUSE	4571	2004

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
			Cell Sum: 120101	
0180	NATURAL RESOURCES	NATURAL RESOURCES	149972	1966
			Cell Sum: 149972	
0181A	CENTER FOR INTEGRATIVE PLANT SYSTEMS - LAB BUILDING	ORIGINAL BUILDING GREENHOUSE	37530	1967
	CENTER FOR INTEGRATIVE PLANT SYSTEMS - LAB BUILDING	ADDITION 1 HEADHOUSE	38776	1969
	CENTER FOR INTEGRATIVE PLANT SYSTEMS - LAB BUILDING	ADDITION 2 POLYGREENHOUSE	13108	2002
	CENTER FOR INTEGRATIVE PLANT SYSTEMS - LAB BUILDING	ADDITION 3 POLYGREENHOUSE	8150	2004
			Cell Sum: 97563	
0182	BAKER HALL	BAKER HALL	60925	1967
			Cell Sum: 60925	
0183	LIFE SCIENCE	LIFE SCIENCE	176394	1971
			Cell Sum: 176394	
0186	FOOD SAFETY AND TOXICOLOGY BUILDING	FOOD SAFETY AND TOXICOLOGY	115133	1997
			Cell Sum:	

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
			115133	
0189	REGIONAL CHILLED WATER PLANT NO. 1	REGIONAL CHILLED WATER PLANT 1	4894	1971
	REGIONAL CHILLED WATER PLANT NO. 1	ADDITION 1	5000	1976
	REGIONAL CHILLED WATER PLANT NO. 1	ADDITION 2	4688	1985
	REGIONAL CHILLED WATER PLANT NO. 1	ADDITION 3	4766	1991
	REGIONAL CHILLED WATER PLANT NO. 1	ADDITION 4	4736	1993
			Cell Sum: 24084	
0200	CLINICAL CENTER - CLINIC WING	CLINICAL CTR-CLINIC	182784	1976
	CLINICAL CENTER - CLINIC WING	ADDITION 1 M.R.C.	4987	1985
	CLINICAL CENTER - CLINIC WING	ADDITION 2 M.R.C.	8586	1988
	CLINICAL CENTER - CLINIC WING	ADDITION 3 RADIOPHARMACEUTICAL	17989	2003
0201	CLINICAL CENTER - OFFICE - LAB. WING	CLINICAL CTR-LAB	77530	1976
0202	CLINICAL CENTER - ANIMAL QUARTERS WING	CLINICAL CTR-ANIMAL QTR	43813	1976
			335689	
0203A	ENGINEERING RESEARCH COMPLEX	ENGINEERING RESEARCH COMPLEX	80728	1986

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
	ENGINEERING RESEARCH COMPLEX	ADDITION 1 NMR	8364	2004
	ENGINEERING RESEARCH COMPLEX	ADDITION 2 ENERGY & AUTOMOT	29543	2007
	ENGINEERING RESEARCH COMPLEX	ADDITION 3 OFFICE ADDITION	2847	2010
			Cell Sum: 121481	
0214	RADIOLOGY BUILDING	RADIOLOGY BUILDING	64773	1998
			Cell Sum: 64773	
0300	SNYDER AND PHILLIPS HALL	PHILLIPS HALL		1947
	SNYDER AND PHILLIPS HALL	SNYDER AND PHILLIPS HALL	204485	1947
	SNYDER AND PHILLIPS HALL	ADDITION 1	96648	2007
			Cell Sum: 301133	
0302	MASON AND ABBOT HALL	ABBOT HALL	189167	1938
	MASON AND ABBOT HALL	MASON HALL (COMBINED W 302		1938
			Cell Sum: 189167	
0304	CAMPBELL HALL	CAMPBELL HALL	80384	1939
	CAMPBELL HALL	ADDITION 1	759	1969
			Cell Sum: 81143	
0305	LANDON HALL	LANDON HALL	81364	1947
	LANDON HALL	ADDITION 1	744	1969

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
			Cell Sum: 82108	
0306	YAKELEY AND GILCHRIST HALL	GILCHRIST HALL (COMBINED W 306		1948
	YAKELEY AND GILCHRIST HALL	YAKELEY HALL	134976	1948
			Cell Sum: 134976	
0308	WILLIAMS HALL	WILLIAMS HALL	67414	1937
			Cell Sum: 67414	
0309	MARY MAYO HALL	MARY MAYO HALL	64307	1931
			Cell Sum: 64307	
0310	BUTTERFIELD HALL	BUTTERFIELD HALL	102632	1954
	BUTTERFIELD HALL	ADDITION 1	690	1962
			Cell Sum: 103322	
0311	RATHER HALL	RATHER HALL	113226	1954
	RATHER HALL	ADDITION 1	729	1962
			Cell Sum: 113955	
0312	BRYAN HALL	BRYAN HALL	116068	1954
			Cell Sum: 116068	
0313	BRODY HALL	BRODY HALL	102842	1954
	BRODY HALL	ADDITION 1	32327	1955
	BRODY HALL	ADDITION 2	433	1979

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
			Cell Sum: 135602	
0314	EMMONS HALL	EMMONS HALL	111729	1955
	EMMONS HALL	ADDITION 1	2063	2011
			Cell Sum: 113793	
0315	BAILEY HALL	BAILEY HALL	112303	1955
			Cell Sum: 112303	
0316	ARMSTRONG HALL	ARMSTRONG HALL	115115	1955
			Cell Sum: 115115	
0317	SHAW HALL	SHAW HALL	275868	1950
			Cell Sum: 275868	
0319	VANHOOSEN HALL	VANHOOSEN HALL	32834	1957
			Cell Sum: 32834	
0320	OWEN GRADUATE HALL	OWEN GRADUATE HALL	162385	1961
	OWEN GRADUATE HALL	ADDITION 1	130032	1965
	OWEN GRADUATE HALL	ADDITION 2 COVER LOADING DOCK	482	2009
			Cell Sum: 292900	
0321	CASE HALL	CASE HALL	284671	1961
	CASE HALL	ADDITION 1	9150	1987
	CASE HALL	ADDITION 2 - LOADING DOCK	1840	2008

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
			Cell Sum: 295661	
0322	WILSON HALL	WILSON HALL	343927	1962
			Cell Sum: 343927	
0323	WONDERS HALL	WONDERS HALL	343260	1963
			Cell Sum: 343260	
0324	MCDONEL HALL	MCDONEL HALL	348499	1963
			Cell Sum: 348499	
0325	UNIVERSITY HOUSING OFFICE	UNIVERSITY HOUSING OFFICE	12080	1962
			Cell Sum: 12080	
0326	AKERS HALL	AKERS HALL	385797	1964
			Cell Sum: 385797	
0327	FEE HALL	FEE HALL	386440	1964
	FEE HALL	ADDITION 1	1631	1972
			Cell Sum: 388072	
0328	CONRAD HALL	CONRAD HALL	23096	1964
			Cell Sum: 23096	
0330	HOLMES HALL	HOLMES HALL	394953	1965
			Cell Sum: 394953	

Table 15 (cont'd)

Building	Entity Official Name	Addn Name	Famis Cad Sqft	Addn Year Built
0331	HUBBARD HALL	HUBBARD HALL	351190	1966
			Cell Sum: 351190	
0332	HOLDEN HALL	HOLDEN HALL	357504	1967
			Cell Sum: 357504	
1100	UNIVERSITY VILLAGE - 1701	UNIVERSITY VILLAGE - 1701	17860	2007
	UNIVERSITY VILLAGE - 1702	UNIVERSITY VILLAGE - 1702	11999	2007
	UNIVERSITY VILLAGE - 1703	UNIVERSITY VILLAGE - 1703	11999	2007
	UNIVERSITY VILLAGE - 1704	UNIVERSITY VILLAGE - 1704	11999	2007
	UNIVERSITY VILLAGE COMMUNITY CENTER	UNIVERSITY VILL COMMUNITY CNTR	2640	2007
	UNIVERSITY VILLAGE - 1706	UNIVERSITY VILLAGE - 1706	11999	2007
	UNIVERSITY VILLAGE - 1707	UNIVERSITY VILLAGE - 1707	11902	2007
	UNIVERSITY VILLAGE - 1708	UNIVERSITY VILLAGE - 1708	17969	2007
	UNIVERSITY VILLAGE - 1709	UNIVERSITY VILLAGE - 1709	17967	2007
			116337	

***Provided by Lynda Boomer**

Appendix F

Engineering Research Complex Reverse Osmosis System

Figure 11: Tempered water is softened and passed through carbon filtration.

Figure 12: The reverse osmosis unit is activated when the reservoir drops to a set level

Figure 13: Purified water is stored in the reservoir.

Figure 14: Before water is circulated through the building, it is passed through an ion-exchange resin, a 22 µm filter and a fluorescent lamp.

Appendix G

Sample Calculations

Average Monthly Water Consumption (residence halls)

Water data from the Fall and Spring semesters was averaged over an 8 month period and then normalized by the occupancy of that building. The sample calculation is for Akers Hall during the 2010-2011 academic year.

$$\frac{Sept.+Oct.+Nov.+Dec.+Jan.+Feb.+Mar.+Apr}{8\ Months}$$

$$\frac{1514+1300+700+1081+1690+1958+1613+1854}{8\ Months}=1464\frac{KGAL}{mo.}$$

$$1464\frac{KGAL}{mo}\ \div 1054\ \ residents=1.389\frac{KGAL}{mo.\times\ person}$$

Average Monthly Water Consumption Change Percentage

The percentage change from the 2009-2010 academic year to the 2010-2011 academic year is given by (where volume is in KGAL per month per person):

$$\frac{Volume\ (2010-2011)-\ Volume\ (2009-2010)}{Volume\ (2009-2010)}$$

For Shaw Hall:

$$\frac{2.9125-2.411}{2.9125}x100\%=20.82\%$$

Water and Cost savings for Bryan Hall

Water savings per month (KGAL):

$$\begin{aligned} &\mathit{Average\ Monthly\ Water\ Usage\ Before\ Renovation} \\ &\qquad - \mathit{Average\ Monthly\ Water\ Usage\ After\ Renovation} \end{aligned}$$

Average monthly water usage before renovation was an average of water data from July 2004 to June 2008. Average monthly water usage after renovation was July 2008 to June 2009 (before meter change) and July 2009 to June 2011 (after meter change).

Before meter change:

The average of the monthly water data from 2004-2008 was 1190 KGAL/mo.

The average of the monthly water data from 2008-2009 was 404 KGAL/mo.

Water savings that resulted from the bathroom renovation is therefore:

$$1190\,\frac{KGAL}{mo.} - 404\,\frac{KGAL}{mo.} = 786\,\frac{KGAL}{mo.}\ savings$$

Cost savings per month:

$$786\,\frac{KGAL}{mo} \times \$4.70\,\frac{\$}{KGAL} = \$3{,}691\ per\ month$$

Payback period:

$$\$44{,}814\ project\ cost\ \div \$3{,}691\ per\ month = 12.14\ months = 1.01\ years$$

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